Allen-Bradley

PowerFlex®

70 Enhanced Control and 700 Vector Control

Reference Manual

Rockwell Automation

Important User Information

Solid state equipment has operational characteristics differing from those of electromechanical equipment. *Safety Guidelines for the Application, Installation and Maintenance of Solid State Controls* (Publication SGI-1.1 available from your local Rockwell Automation sales office or online at **www.rockwellautomation.com/literature**) describes some important differences between solid state equipment and hard-wired electromechanical devices. Because of this difference, and also because of the wide variety of uses for solid state equipment, all persons responsible for applying this equipment must satisfy themselves that each intended application of this equipment is acceptable.

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Throughout this manual, when necessary we use notes to make you aware of safety considerations.

WARNING: Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.

Important: Identifies information that is critical for successful application and understanding of the product.

ATTENTION: Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss. Attentions help you:

- identify a hazard
- avoid the hazard
- recognize the consequences

Shock Hazard labels may be located on or inside the equipment (e.g., drive or motor) to alert people that dangerous voltage may be present.

Burn Hazard labels may be located on or inside the equipment (e.g., drive or motor) to alert people that surfaces may be at dangerous temperatures.

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Overview

The purpose of this manual is to provide detailed drive information including operation, parameter descriptions and programming.

Manual Conventions

This manual covers the PowerFlex 70EC and the PowerFlex 700VC Drives. Some of the information presented applies to specific drives. The following symbols will be used throughout to identify specific drive information.

Symbol	Information pertains to ...
	PowerFlex 70 Enhanced Control (EC) drive
	PowerFlex 700 Vector Control (VC) drive

Reference Materials

In addition to the User Manual for your drive, the following manuals are recommended for general drive information:

Title	Publication	Available Online at . . .
Wiring and Grounding Guidelines for PWM AC Drives	DRIVES-IN001...	**www.rockwellautomation.com/literature**
Preventive Maintenance of Industrial Control and Drive System Equipment	DRIVES-TD001...	
Safety Guidelines for the Application, Installation and Maintenance of Solid State Control	SGI-1.1	

For Allen-Bradley Drives Technical Support:

Title	Online at . . .
Allen-Bradley Drives Technical Support	**www.ab.com/support/abdrives**

To help differentiate parameter names and LCD display text from other text, the following conventions will be used:

- Parameter Names will appear in [brackets]. For example: [DC Bus Voltage].
- Display Text will appear in “quotes.” For example: “Enabled.”
- The following words are used throughout the manual to describe an action:

Word	Meaning
Can	Possible, able to do something
Cannot	Not possible, not able to do something
May	Permitted, allowed
Must	Unavoidable, you must do this
Shall	Required and necessary
Should	Recommended
Should Not	Not recommended

General Precautions

ATTENTION: This drive contains ESD (Electrostatic Discharge) sensitive parts and assemblies. Static control precautions are required when installing, testing, servicing or repairing this assembly. Component damage may result if ESD control procedures are not followed. If you are not familiar with static control procedures, reference A-B publication 8000-4.5.2, “Guarding Against Electrostatic Damage” or any other applicable ESD protection handbook.

ATTENTION: An incorrectly applied or installed drive can result in component damage or a reduction in product life. Wiring or application errors, such as, undersizing the motor, incorrect or inadequate AC supply, or excessive ambient temperatures may result in malfunction of the system.

ATTENTION: Only qualified personnel familiar with adjustable frequency AC drives and associated machinery should plan or implement the installation, start-up and subsequent maintenance of the system. Failure to comply may result in personal injury and/or equipment damage.

ATTENTION: To avoid an electric shock hazard, verify that the voltage on the bus capacitors has discharged before performing any work on the drive. Measure the DC bus voltage at the +DC & –DC terminals of the Power Terminal Block (refer to the User Manual for location). The voltage must be zero.

ATTENTION: Risk of injury or equipment damage exists. DPI or SCANport host products must not be directly connected together via 1202 cables. Unpredictable behavior can result if two or more devices are connected in this manner.

ATTENTION: An incorrectly applied or installed bypass system can result in component damage or reduction in product life. The most common causes are:

- Wiring AC line to drive output or control terminals.
- Improper bypass or output circuits not approved by Allen-Bradley.
- Output circuits which do not connect directly to the motor.
- Contact Allen-Bradley for assistance with application or wiring.

ATTENTION: Loss of control in suspended load applications can cause personal injury and/or equipment damage. Loads must always be controlled by the drive or a mechanical brake. Parameters 600-611 are designed for lifting/torque proving applications. It is the responsibility of the engineer and/or end user to configure drive parameters, test any lifting functionality and meet safety requirements in accordance with all applicable codes and standards.

Detailed Drive Operation

This chapter explains PowerFlex drive functions in detail. Explanations are organized alphabetically by topic. Refer to the Table of Contents for a listing of topics.

Accel/Decel Time

[Accel Time 1, 2]
[Decel Time 1, 2]

The Accel Time parameters set the rate at which the drive ramps its output frequency after a Start or Stop command or during a change in command frequency (speed **change**). The rate established is the result of the programmed Accel or Decel Time and the Maximum Frequency.

$$\frac{\text{Maximum Speed}}{\text{Accel Time}} = \text{Accel Rate (Hz/sec.)} \qquad \frac{\text{Maximum Speed}}{\text{Decel Time}} = \text{Decel Rate (Hz/sec.)}$$

Two accel and decel times exist to allow the user to change rates "on the fly" via PLC command or digital input. Times are adjustable in 0.1 second increments from 0.0 seconds to 3600.0 seconds.

In its factory default condition, the secondary accel/decel times are not active if the related digital input functions or network commands have not been invoked.

Alarms

Alarms are indications of situations that are occurring within the drive or application that should be annunciated to the user. These situations may affect the drive operation or application performance. Conditions such as Power Loss or Analog input signal loss can be detected and displayed for drive or operator action.

There are two types of alarms:

- **Type 1 Alarms** are conditions that by themselves, do not cause the drive to "trip" or shut down, but they may be an indication that, if the condition persists, it may lead to a drive fault.
- **Type 2 Alarms** are conditions that are caused by improper programming and they prevent the drive from Starting until programming is corrected. An example of a Type 2 alarm is when a "Start" function is assigned to a digital input without a "Stop" function also assigned to a digital input.

Alarm Status Indication

[Drive Alarm 1]
[Drive Alarm 2]

Drive Alarm 1 is 16 bit parameter with each bit representing a specific Type 1 Alarm. Drive Alarm 2 is 16 bit parameter with each bit representing a specific Type 2 Alarm. For each Drive Alarm bit, *0 = alarm not active* and *1 = alarm active*.

Configuration

Type 2 Alarms are always enabled (not configurable). Type 1 Alarms will always be displayed in [Drive Alarm 1], but can be configured to either mask or allow specific alarms from a) turning on the “Alarm” bit within the [Drive Status 1] parameter and b) turning on a digital output when [Digital Outx Sel] is set to “Alarm.”

For each Alarm Config bit, *0 = alarm disabled* and *1 = alarm enabled*.

Drive Alarm															
													1	1	1
Alarm Config													↓	↓	↓
													1	0	0
													↓	**X**	**X**
													Active Alarm	Inactive Alarm	Inactive Alarm

Analog Inputs

70EC ✓ 700VC ✓

Possible Uses of Analog Inputs

The analog inputs provide data that can be used for the following purposes:

- Provide a value to [Speed Ref A] or [Speed Ref B].
- Provide a trim signal to [Speed Ref A] or [Speed Ref B].
- Provide a reference when the terminal block has assumed manual control of the reference
- Provide a reference and/or feedback for the PI loop. See "Process PID Loop" on page 77.
- Provide an external and adjustable value for the current limit and DC braking level
- Start and Stop control using the Sleep/Wake mode.
- Provide a value to [Torque Ref A] or [Torque Ref B].

Analog Scaling

[Analog In x Lo]
[Analog In x Hi]

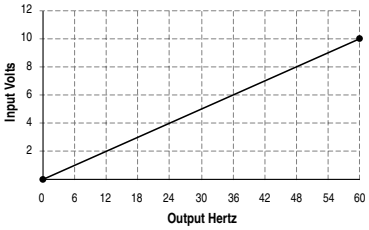
A scaling operation is performed on the value read from an analog input in order to convert it to units usable for some particular purpose. The user controls the scaling by setting parameters that associate a low and high analog value (e.g. in volts or mA) with a low and high target (e.g. Hz).

For many features such as Current Limit and DC Brake Level, the target scaling values are fixed (not adjustable) to the minimum and maximum of the selected function. However, the PowerFlex 700 contains “Scale Blocks” for additional flexibility (refer to page 91).

Example 1

– [Anlg In Config], bit 0 = “0” (Voltage)
– [Speed Ref A Sel] = “Analog In 1”
– [Speed Ref A Hi] = 60 Hz
– [Speed Ref A Lo] = 0 Hz
– [Analog In 1 Hi] = 10V
– [Analog In 1 Lo] = 0V

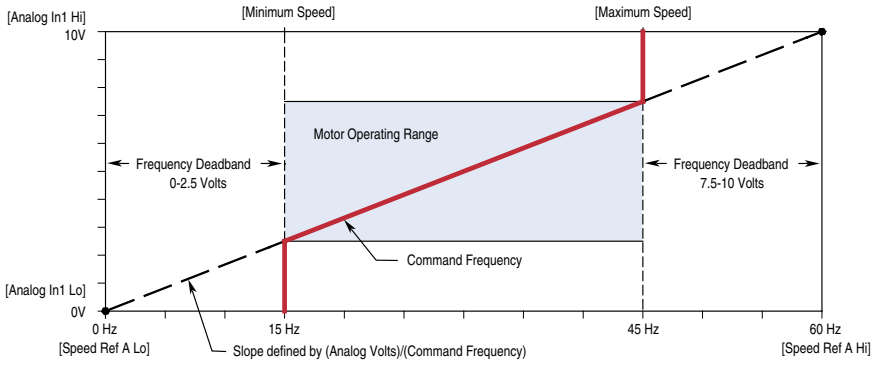
This is the default setting, where 0 volts represents 0 Hz and 10 volts represents 60 Hz providing 1024 steps (10 bit analog input resolution) between 0 and 60 Hz.



Example 2

Consider the following setup:
– [Anlg In Config], bit 0 = “0” (voltage)
– [Speed Ref A Sel] = “Analog In 1”
– [Analog In1 Hi] = 10V
– [Analog In1 Lo] = 0V
– [Speed Ref A Hi] = 60 Hz
– [Speed Ref A Lo] = 0 Hz
– [Maximum Speed] = 45 Hz
– [Minimum Speed] = 15 Hz

This configuration is used when non-default settings are desired for minimum and maximum speeds, but full range (0-10V) scaling from 0-60 Hz is still desired.

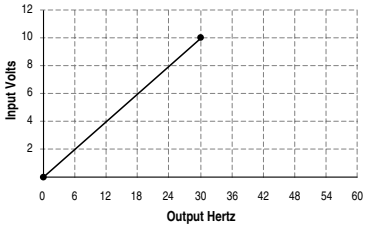


In this example, a deadband from 0-2.5 volts and from 7.5-10 volts is created. Alternatively, the analog input deadband could be eliminated while maintaining the 15 and 45 Hz limits with the following changes:
– [Speed Ref A Lo] = 15 Hz
– [Speed Ref A Hi] = 45 kHz

Example 3

- [Anlg In Config], bit 0 = “0” (Voltage)
- [Speed Ref A Sel] = “Analog In 1”
- [Speed Ref A Hi] = 30 Hz
- [Speed Ref A Lo] = 0 Hz
- [Analog In 1 Hi] = 10V
- [Analog In 1 Lo] = 0V

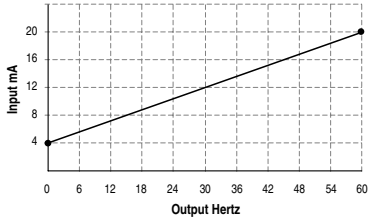
This is an application that only requires 30 Hz as a maximum output frequency, but is still configured for full 10 volt input. The result is that the resolution of the input has been doubled, providing 1024 steps between 0 and 30 Hz.



Example 4

- [Anlg In Config], bit 0 = “1” (Current)
- [Speed Ref A Sel] = “Analog In 1”
- [Speed Ref A Hi] = 60 Hz
- [Speed Ref A Lo] = 0 Hz
- [Analog In 1 Hi] = 20 mA
- [Analog In 1 Lo] = 4 mA

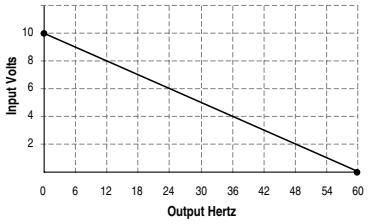
This configuration is referred to as offset. In this case, a 4-20 mA input signal provides 0-60 Hz output, providing a 4 mA offset in the speed command.



Example 5

- [Anlg In Config], bit 0 = “0” (Voltage)
- [Speed Ref A Sel] = “Analog In 1”
- [Speed Ref A Hi] = 0 Hz
- [Speed Ref A Lo] = 60 Hz
- [Analog In 1 Hi] = 10V
- [Analog In 1 Lo] = 0V

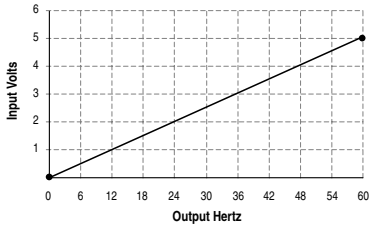
This configuration is used to invert the operation of the input signal. Here, maximum input (10 Volts) represents 0 Hz and minimum input (0 Volts) represents 60 Hz.



Example 6

- [Anlg In Config], bit 0 = “0” (Voltage)
- [Speed Ref A Sel] = “Analog In 1”
- [Speed Ref A Hi] = 60 Hz
- [Speed Ref A Lo] = 0 Hz
- [Analog In 1 Hi] = 5V
- [Analog In 1 Lo] = 0V

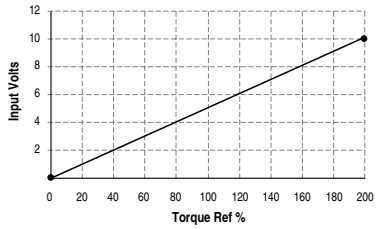
This configuration is used when the input signal is 0-5 volts. Here, minimum input (0 Volts) represents 0 Hz and maximum input (5 Volts) represents 60 Hz. This allows full scale operation from a 0-5 volt source.



Example 7

- [Anlg In Config], bit 0 = “0” (Voltage)
- [Torque Ref A Sel] = “Analog In 1”
- [Torque Ref A Hi] = 200%
- [Torque Ref A Lo] = 0%
- [Torque Ref A Div] = 1 (PowerFlex 700VC Only)

This configuration is used when the input signal is 0-10 volts. The minimum input of 0 volts represents a torque reference of 0% and maximum input of 10 volts represents a torque reference of 200%.



Square Root

The square root function can be applied to each analog input through the use of [Analog In Sq Root]. The function should be enabled if the input signal varies with the square of the quantity (e.g. drive speed) being controlled.

If the mode of the input is bipolar voltage (–10v to 10v), then the square root function will return 0 for all negative voltages.

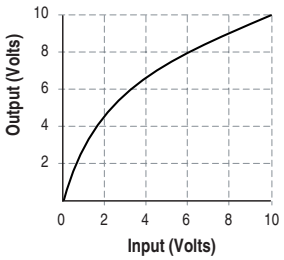
The function uses the square root of the analog value as compared to its full scale (e.g. 5V = 0.5 or 50% and $\sqrt{0.5} = 0.707$) and multiplies it times the full scale of what it will control (e.g. 60 Hz).

The complete function can be describes as:

$$\left(\sqrt{\frac{\text{Analog Value - [Analog In x Lo]}}{\text{[Analog In x Hi] - [Analog In x Lo]}}}\right) \times \left(\text{[Speed Ref A Hi]} - \text{[Speed Ref A Lo]}\right) + \text{[Speed Ref A Lo]}$$

Setting high and low values to 0V, 10V, 0 Hz and 60 Hz, the expression reduces to:

$$\left(\sqrt{\frac{\text{Analog Value}}{\text{10V}}}\right) \times 60\ \text{Hz}$$



Signal Loss

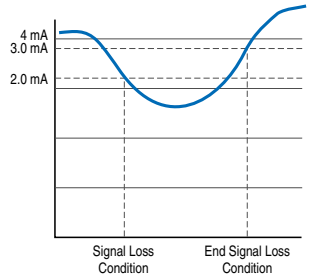
Signal loss detection can be enabled for each analog input. The [Analog In x Loss] parameters control whether signal loss detection is enabled for each input and defines what action the drive will take when loss of any analog input signal occurs.

One of the selections for reaction to signal loss is a drive fault, which will stop the drive. All other choices make it possible for the input signal to return to a usable level while the drive is still running.

- Hold input
- Set input Lo
- Set input Hi
- Goto Preset 1
- Hold Output Frequency

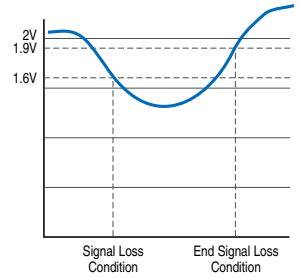
[Analog In x Loss]	Normal Operation	Operation with Analog Selected as Process PID Fdbk Exclusive Mode	Operation with Analog Selected as Process PID Fdbk Trim Mode
0, “Disabled” (default)	Disabled	Disabled	Disabled
1, “Fault”	Faults	Faults	Faults
2, “Hold Input”	Holds speed at last valid analog input level.	Disables PID and follows selected speed reference.	Disables PID and follows selected speed reference.
3, “Set Input Lo”	Follows the maximum of [Minimum Speed] or [Speed Ref x Lo].	Disables PID and follows selected speed reference.	Disables PID and follows selected speed reference.
4, “Set Input Hi”	Follows the minimum of [Maximum Speed] or [Speed Ref x Hi].	Disables PID and follows selected speed reference	Disables PID and follows selected speed reference
5, “Goto Preset1”	Follows [Preset Speed 1].	Follows [Preset Speed 1]	Follows [Preset Speed 1]
6, “Hold OutFreq”	Follows the last commanded output frequency.	Disables PID and follows the last commanded output frequency.	Disables PID and follows selected speed reference.

If the input is in current mode, 4 mA is the normal minimum usable input value. Any value below 2.0 mA will be interpreted by the drive as a signal loss, and a value of 3.0 mA will be required on the input in order for the signal loss condition to end.



If the input is in unipolar voltage mode, 2V is the normal minimum usable input value. Any value below 1.0 volts will be interpreted by the drive as a signal loss, and a value of 1.5 volts will be required on the input in order for the signal loss condition to end.

No signal loss detection is possible while an input is in bipolar voltage mode. The signal loss condition will never occur even if signal loss detection is enabled.



Value Display

Parameters are available in the Monitoring Group to view the actual value of an analog input regardless of its use in the application.

The value displayed includes the input value plus any factory hardware calibration value, but does not include scaling information programmed by the user (e.g. [Analog In 1 Hi/Lo]). The units displayed are determined by configuration of the input.

Analog Outputs

70EC 700VC

Each drive has one or more analog outputs that can be used to annunciate a wide variety of drive operating conditions and values. The user selects the analog output source by setting [Analog Out Sel].

Configuration

The analog outputs have 10 bits of resolution yielding 1024 steps. The analog output circuit has a maximum 1.3% gain error and a maximum 100 mV offset error. For a step from minimum to maximum value, the output will be within 0.2% of its final value after 12ms.

Absolute (default)

Certain quantities used to drive the analog output are signed, e.g. the quantity can be both positive and negative. The user has the option of having the absolute value (value without sign) of these quantities taken before the scaling occurs. Absolute value is enabled separately for each analog output via the bit enumerated parameter [Anlg Out Absolut].

Scaling

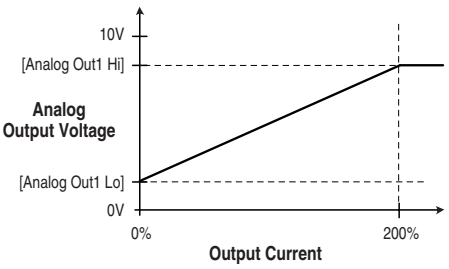
The scaling for the analog output is defined by entering analog output voltages into two parameters, [Analog Out1 Lo] and [Analog Out1 Hi]. These two output voltages correspond to the bottom and top of the possible range covered by the quantity being output. Scaling of the analog outputs is accomplished with low and high analog parameter settings that are associated with fixed ranges (see User Manual) for each target function. Additionally, the PowerFlex 700VC contains an adjustable scale factor to override the fixed target range.

Examples

This section gives a few examples of valid analog output configurations and describes the behavior of the output in each case.

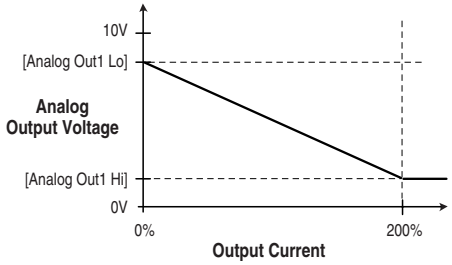
Example 1: Unsigned Output Quantity

- [Analog Out1 Sel] = “Output Current”
- [Analog Out1 Lo] = 1 volt
- [Analog Out1 Hi] = 9 volts



Example 2: Unsigned Output Quantity, Negative Slope

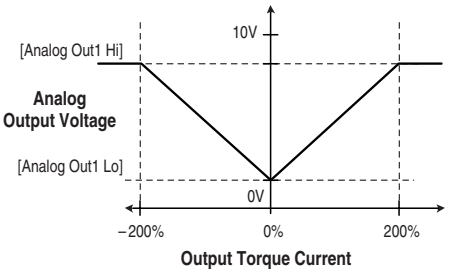
- [Analog Out1 Sel] = “Output Current”
- [Analog Out1 Lo] = 9 volts
- [Analog Out1 Hi] = 1 volts



This example shows that [Analog Out1 Lo] can be greater than [Analog Out1 Hi]. The result is a negative slope on the scaling from original quantity to analog output voltage. Negative slope could also be applied to any of the other examples in this section.

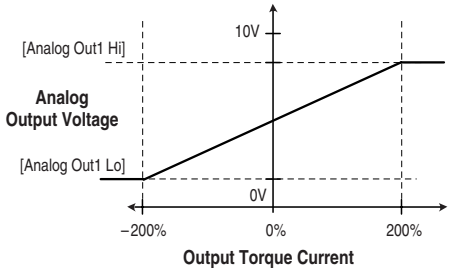
Example 3: Signed Output Quantity, Absolute Value Enabled

- [Analog Out1 Sel] = “Output Torque Current”
- [Analog Out1 Lo] = 1 volt
- [Analog Out1 Hi] = 9 volts
- [Anlg Out Absolut]



Example 4: Signed Output Quantity, Absolute Value Disabled

- [Analog Out1 Sel] = “Output Torque Current”
- [Analog Out1 Lo] = 1 volt
- [Analog Out1 Hi] set to 9 volts
- [Anlg Out Absolut]



Example 5: Overriding the Default Analog Output Target Scaling

Analog Output 1 set for 0-10V DC at 0-100% Commanded Torque. Setup:

- [Analog Out1 Sel], parameter 342 = 14 “Commanded Torque”
- [Analog Out1 Hi], parameter 343 = 10.000 Volts
- [Analog Out1 Lo], parameter 344 = 0.000 Volts
- [Anlg Out1 Scale], parameter 354 = 100.0 (PowerFlex 700VC Only)

If [Analog Out1 Lo] = –10.000 Volts the output will be –10.0 to +10.0V DC for –100% to +100% Commanded Torque.

If [Anlg Out1 Scale] = 0.0, the default scaling listed in [Analog Out1 Sel] will be used. This would be 0-10V DC for 0-800% torque.

Filtering

Software filtering is performed on quantities that can be monitored as described in the following table. The purpose of this filtering is to provide a signal and display that is less sensitive to noise and ripple.

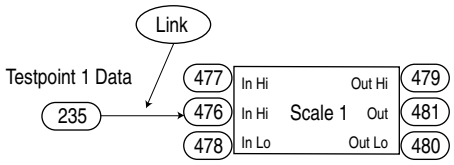
Software Filters

Quantity	Filter
Output Frequency	No Filtering
Commanded Frequency	Filtered
Output Current	Filtered
Output Torque Current	Filtered
Output Flux Current	Filtered
Output Power	Filtered
Output Voltage	Filtered
DC Bus Voltage	Filtered
PI Reference	No Filtering
PI Feedback	No Filtering
PI Error	No Filtering
PI Output	No Filtering

Scale Block Analog Output *700VC ONLY*

In addition to the common selections, an analog output can be driven by any available data. The data can then be scaled before it reaches the output. A “Link” function establishes a connection from the data to the input of a “Scale Block.”

The analog output selection “Scale Block x” makes the connection from the output of the scale block to the physical output.



Example

Analog Output 2 set for 0-10V DC for Heat Sink Temp 0-100 Degrees C. using Scale Block 1. Setup:

- Link [Scale1 In Value], parameter 476 to [Testpoint 1 Data], param. 235
- [Testpoint 1 Sel], parameter 234 = 2 “Heat Sink Temp”
- [Analog Out2 Sel], parameter 345 = 20 “Scale Block 1”
- [Analog Out2 Hi], parameter 346 = 10.000 Volts
- [Analog Out2 Lo], parameter 347 = 0.000 Volts
- [Scale1 In Hi], parameter 477 = 100
- [Scale1 In Lo], parameter 478 = 0

Network Controlled Analog Output

Enables the analog outputs to be controlled by network Datalinks to the drive.

Example

Analog Output 1 controlled by DataLink C1. Output 0-10V DC with DataLink values of 0-10000. Setup:

- [Data In C1], parameter = 304 “Analog Output 1 Setpoint”
- [Analog Out1 Sel], parameter 342 = 24 “Parameter Control”
- [Analog Out1 Hi], parameter 343 = 10.000 Volts
- [Analog Out1 Lo], parameter 344= 0.000 Volts

The device that writes to DataLink C1 now controls the voltage output of Analog Out1. For example: 2500 = 2.5V DC, 5000 = 5.0V DC, 7500 = 7.5V DC.

Auto/Manual

The purpose of the Auto/Manual function is to permit temporary override of speed control, or both speed control and start (run)/stop control. Each connected HIM or the control terminal block is capable of performing this function. However, only one device may own “Manual” control and must release the drive back to “Auto” control before another device can be granted “Manual” control. The network or digital input control function named “local,” has priority over the Auto/Manual function.

The HIM can request or release Manual control by pressing the “Alt” key followed by the “Auto/Man” key. When the HIM is granted manual control, the drive uses the speed reference in the HIM. If desired, the auto speed reference can be automatically preloaded into the HIM when entering HIM manual control, so that the transition is smooth.

To use manual control from the terminal block, a digital input must be programmed to the “Auto/Man” selection. In this case, the speed control comes from the setting in [TB Man Ref Sel], and is limited to terminal block sources.

By default, only the speed reference (not Start or Jog control) changes when toggling between Auto and Manual. However, it is possible for both Speed Reference and Start/Jog control to change when toggling between Auto and Manual.

Refer to the appropriate parameter description for your drive and the tables that follow for detailed operation.

PowerFlex 70: Parameter 192, [AutoMan Cnfg]
PowerFlex 700: Parameter 192, [Save HIM Ref]

Table A Parameter Bit Definitions

Bit		Definition
0	Save HIM Ref	0 = Disabled, 1 = Enabled Saves the HIM reference at power-down and reloads it at power-up.
1	Manual Mode	0 = Disabled, 1 = Enabled Adds exclusive HIM start/jog control while in manual mode.
2(1)	ManRefPrld	0 = Disabled, 1 = Enabled Preloads the auto reference into the HIM upon transition from Auto to Manual.
3	HIM Disable	0 = HIM starts, 1 = HIM doesn't start HIM Start/Jog operation while in 3 wire Auto mode.

(1) PowerFlex 70 Only. PowerFlex 700 functionality is handled in parameter 193.

Table B Bit Combinations and Results

Parameter 192			Auto Control		HIM Manual Control	
Bit 3 =	Bit 1 =	Terminals Programmed for	HIM Starts Drive (Y/N)?	Terminal Block Starts Drive (Y/N)?	HIM Starts Drive (Y/N)?	Terminal Block Starts Drive (Y/N)?
0(1)	0(1)	2 wire	N	Y	N	Y
		3 wire	Y	Y	Y	Y
0	1	2 wire	N	Y	Y	N
		3 wire	Y	Y	Y	N
1	0	2 wire	Same as 0 0	Same as 0 0	Same as 0 0	Same as 0 0
		3 wire	Same as 0 0	Same as 0 0	Same as 0 0	Same as 0 0
1	1	2 wire	N	Y	Y	N
		3 wire	N	Y	Y	N

(1) Default setting.

General Rules

The following rules apply to the granting and releasing of Manual control:

1. Manual control is requested through a one-time request (Auto/Man toggle, not continuously asserted). Once granted, the terminal holds Manual control until the Auto/Man button is pressed again, which releases Manual control (e.g. back to Auto mode).
2. Manual control can be granted to a device only if another device does not presently own Manual control.
3. Local control has priority over Manual control and can terminate the manual state of a device.
4. Any connected HIM will indicate when it has been granted Manual control, but will not indicate the manual status of other devices.
5. If the drive is configured such that the HIM can not select the reference (via Reference Mask setting), the drive will not allow the HIM to acquire Manual control. If the Reference Mask for a device's port becomes masked while that device is in Manual control, then Manual control will be released.
6. If a terminal has Manual control and clears its DPI logic mask (allowing disconnect of the terminal), then Manual control will be released. If the drive is configured such that the HIM can be unplugged (via logic mask setting), then the drive will not allow the terminal to acquire Manual control. The disconnect also applies to a HIM that executes a Logout. If the Logic Mask for a device's port becomes masked while that device is in Manual control, then Manual control will be released.
7. If a com loss fault occurs on a device that has Manual control, then Manual control will be released.
8. Manual control cannot be granted to a device which is already assigned as a reference in Auto mode.
9. When a restore factory defaults is performed Manual control is aborted.

Auto Restart

The Auto Restart feature provides the ability for the drive to automatically perform a fault reset followed by a start attempt without user or application intervention. This allows remote or “unattended” operation. Only certain faults are allowed to be reset. Certain faults (Type 2) that indicate possible drive component malfunction are not resettable.

Caution should be used when enabling this feature, since the drive will attempt to issue its own start command based on user selected programming.

Configuration

Setting [Auto Rstrt Tries] to a value greater than zero will enable the Auto Restart feature. Setting the number of tries equal to zero will disable the feature.

The [Auto Rstrt Delay] parameter sets the time, in seconds, between each reset/run attempt.

The auto reset/run feature supports the following status information:

Parameter 210 [Drive Status 2], bit 8 - “Auto Rst Ctdn”
Provides indication that an Auto Restart attempt is presently timing out and the drive will start at the end of the timing event.

Parameter 210 [Drive Status 2], bit 9 - “Auto Rst Act”
Indicates that the drive has been programmed for the Auto Restart function.

The typical steps performed in an Auto Reset/Run cycle are as follows:

1. The drive is running and an auto resettable fault occurs, tripping the drive.
2. After the number of seconds in [Auto Rstrt Delay], the drive will automatically perform an internal Fault Reset, resetting the faulted condition.
3. The drive will then issue an internal Start command to start the drive.
4. If another auto resettable fault occurs the cycle will repeat itself up to the number of attempts set in [Auto Rstrt Tries].
5. If the drive faults repeatedly for more than the number of attempts set in [Auto Rstrt Tries] with less than five minutes between each fault, the auto reset/run is considered unsuccessful and the drive remains in the faulted state.
6. Aborting an Auto Reset/Run Cycle (see Aborting an Auto-Reset/Run Cycle for details).
7. If the drive remains running for five minutes or more since the last reset/run without a fault, or is otherwise stopped or reset, the auto reset/run is considered successful. The entire process is reset to the beginning and will repeat on the next fault.

Beginning an Auto-Reset/Run Cycle

The following conditions must be met when a fault occurs for the drive to begin an auto reset/run cycle.

- The fault must be defined as an auto resettable fault
- [Auto Rstrt Tries] setting must be greater than zero.
- The drive must have been running, not jogging, not autotuning, and not stopping, when the fault occurred. (Note that a DC Brake state is part of a stop sequence and therefore is considered stopping.)

Aborting an Auto-Reset/Run Cycle

During an auto reset/run cycle the following actions/conditions will abort the reset/run attempt process.

- Issuing a stop command from any source. (Note: Removal of a 2-wire run-fwd or run-rev command is considered a stop assertion).
- Issuing a fault reset command from any source.
- Removal of the *enable* input signal.
- Setting [Auto Rstrt Tries] to zero.
- A fault which is not auto resettable.
- Removing power from the drive.
- Exhausting an Auto Reset/Run Cycle

After all [Auto Rstrt Tries] have been made and the drive has not successfully restarted and remained running for five minutes or more, the auto reset/run cycle will be considered exhausted and therefore unsuccessful. In this case the auto reset/run cycle will terminate and an additional fault, "Auto Rstrt Tries" (Auto Restart Tries) will be issued if bit 5 of [Fault Config 1] = "1."

Autotune

Description of parameters determined by the autotune tests.

Flux Current Test

[Flux Current Ref] is set by the flux current test, and is the reactive portion of the motor current (portion of the current that is out of phase with the motor voltage) and is used to magnetize the motor. The flux current test is used to identify the value of motor flux current required to produce rated motor torque at rated current. When the flux test is performed, the motor will rotate. The drive accelerates the motor to approximately two-thirds of base speed and then coasts for several seconds.

IR Voltage Drop Test

[IR Voltage Drop] is set by the IR voltage drop test, and is used to provide additional voltage to offset the voltage drop developed across the stator resistance. An accurate calculation of the [IR Voltage Drop] will ensure higher starting torque and better performance at low speed operation. The motor does not rotate during this test.

Leakage Inductance Test

[Ixo Voltage Drop] is set by the leakage inductance test and measures the inductance characteristics of the motor. A measurement is required to determine references for the regulators that control torque. The motor does not rotate during this test.

Inertia Test

[Total Inertia] is set by the inertia test and represents the time in seconds, for the motor coupled to a load to accelerate from zero to base speed at rated motor torque. During this test, the motor is accelerated to approximately 2/3 of base motor speed. This test is performed during the Start-up mode, but can be manually performed by setting [Inertia Autotune] to "Inertia Tune". The [Total Inertia] and [Speed Desired BW] automatically determine the [Ki Speed Loop] and [Kp Speed Loop] gains for the speed regulator.

Autotune Procedure for Sensorless Vector and Economizer

The purpose of Autotune is to identify the motor flux current and stator resistance for use in Sensorless Vector Control and Economizer modes.

The user must enter motor nameplate data into the following parameters for the Autotune procedure to obtain accurate results:

- [Motor NP FLA]
- [Motor NP Volts]
- [Motor NP Hertz]
- [Motor NP Power]

Next, the Dynamic or Static Autotune should be performed:

- Dynamic - the motor shaft will rotate during this test. The dynamic autotune procedure determines both the stator resistance and motor flux current. The test to identify the motor flux current requires the load to be uncoupled from the motor to find an accurate value. If this is not possible then the static test can be performed.
- Static - the motor shaft does not rotate during this test. The static test determines only [IR Voltage Drop]. This test does not require the load to be uncoupled from the motor.

The static and dynamic tests can be performed during the Start-up routine on the LCD HIM. The tests can also be run manually by setting the value of the [Autotune] parameter to 1 “Static Tune” or 2 “Rotate Tune”.

Alternate Methods for [IR Voltage Drop] & [Flux Current Ref]

If it is not possible or desirable to run the Autotune tests use one of the following two methods:

- When [Autotune] is set to 3 “Calculate”, any changes made by the user to motor nameplate FLA, HP, Voltage, or Frequency activates a new calculation. This calculation is based on a typical motor with those nameplate values.
- If the stator resistance and flux current of the motor are known, voltage drop across the stator resistance can be calculated. Then set [Autotune] to 0 “Ready” and directly enter these values into the [Flux Current] and [IR Voltage Drop] parameters.

Autotune Procedure for Flux Vector

For FVC vector control an accurate model of the motor must be used. For this reason, the motor data must be entered and the autotune tests should be performed with the connected motor.

Motor nameplate data must be entered into the following parameters for the Autotune procedure to obtain accurate results:

- [Motor NP Volts]
- [Motor NP FLA]
- [Motor NP Hertz]
- [Motor NP RPM]
- [Motor NP Power]
- [Motor Poles]

Next the Dynamic or Static Autotune should be performed.

Refer to the "Autotune Procedure for Sensorless Vector and Economizer" on page 17 for a description of these tests.

After the Static or Dynamic Autotune, the Inertia test should be performed. The motor shaft will rotate during the inertia test. During the inertia test the motor should be coupled to the load to find an accurate value. The inertia test can be performed during the Start-up routine on the LCD HIM. The inertia test can also be run manually by setting [Inertia Autotune] to 1 “Inertia Tune”, and then starting the drive.

Troubleshooting the Autotune Procedure

If any errors are encountered during the Autotune process, or the procedure is aborted by the user:

- drive parameters are not changed
- the appropriate fault code will be displayed in the fault queue
- [Autotune] parameter is reset to 0.

The following conditions will generate a fault during an Autotune procedure:

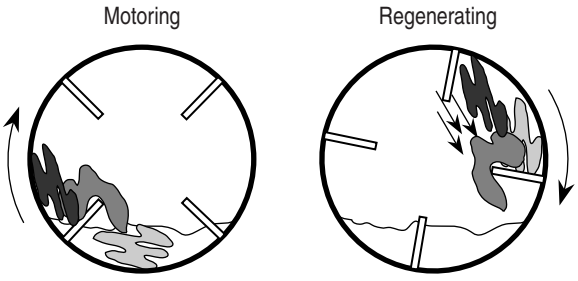
- Incorrect stator resistance measurement
- Incorrect motor flux current measurement
- Load too large
- Autotune aborted by user
- Incorrect leakage inductance measurement

Bus Regulation

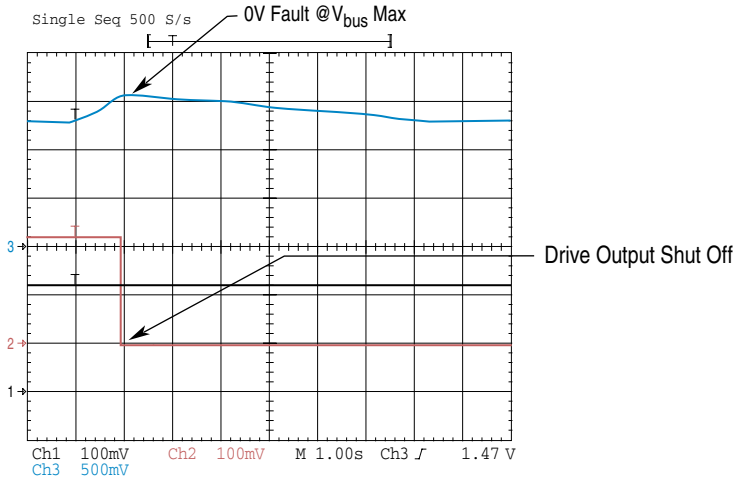
70EC ✓ 700VC ✓

Some applications create an intermittent regeneration condition. The following example illustrates such a condition. The application is hide tanning, in which a drum is partially filled with tanning liquid and hides. When the hides are being lifted (on the left), motoring current exists. However, when the hides reach the top and fall onto a paddle, the motor regenerates power back to the drive, creating the potential for an overvoltage fault.

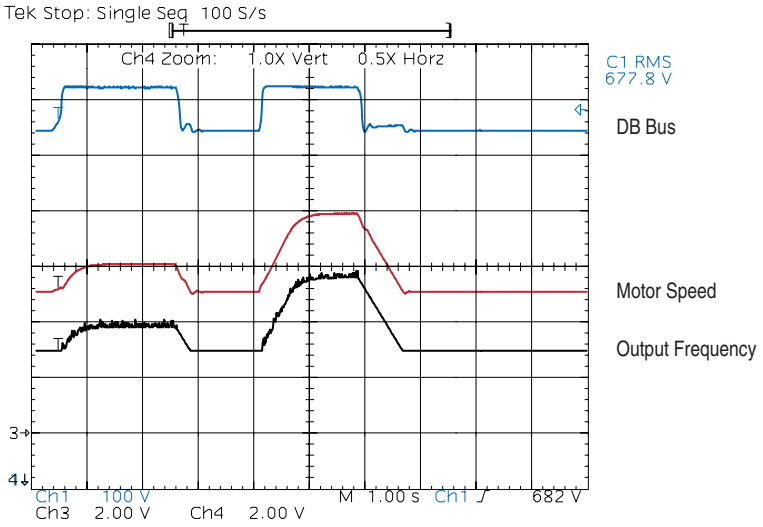
When an AC motor regenerates energy from the load, the drive DC bus voltage increases unless there is another means (dynamic braking chopper/resistor, etc.) of dissipating the energy, or the drive takes some corrective action prior to the overvoltage fault value.



With bus regulation disabled, the bus voltage can exceed the operating limit and the drive will fault to protect itself from excess voltage.



With bus regulation enabled, the drive can respond to the increasing voltage by advancing the output frequency until the regeneration is counteracted. This keeps the bus voltage at a regulated level below the trip point.



The bus voltage regulator takes precedence over acceleration/deceleration. See Figure 1.

Bus voltage regulation is selected by the user in the Bus Reg Mode parameter.

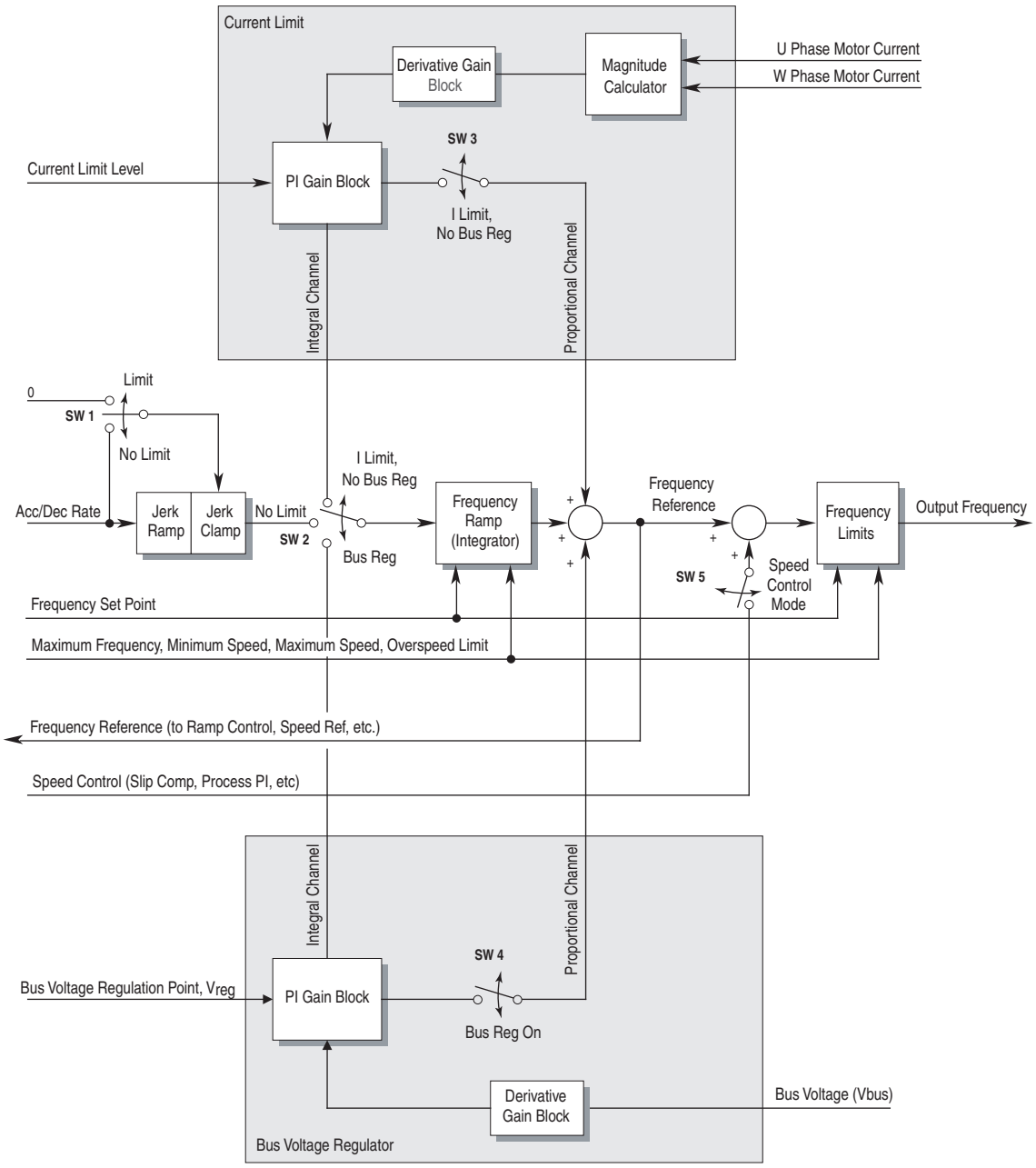
Operation

Bus voltage regulation begins when the bus voltage exceeds the bus voltage regulation set point Vreg and the switches shown in Figure 1 move to the positions shown in .

Switch Positions for Bus Regulator Active

	SW 1	SW 2	SW 3	SW 4	SW 5
Bus Regulation	Limit	Bus Reg	Open	Closed	Don't Care

Figure 1 Bus Voltage Regulator, Current Limit and Frequency Ramp.



The derivative term senses a rapid rise in the bus voltage and activates the bus regulator prior to actually reaching the bus voltage regulation set point Vreg. The derivative term is important since it minimizes overshoot in the bus voltage when bus regulation begins thereby attempting to avoid an over-voltage fault. The integral channel acts as the acceleration or deceleration rate and is fed to the frequency ramp integrator. The proportional term is added directly to the output of the frequency ramp integrator to form the output frequency. The output frequency is then limited to a maximum output frequency.

ATTENTION: The “adjust freq” portion of the bus regulator function is extremely useful for preventing nuisance overvoltage faults resulting from aggressive decelerations, overhauling loads, and eccentric loads. It forces the output frequency to be greater than commanded frequency while the drive's bus voltage is increasing towards levels that would otherwise cause a fault. However, it can also cause either of the following two conditions to occur.

1. Fast positive changes in input voltage (more than a 10% increase within 6 minutes) can cause uncommanded positive speed changes. However an “OverSpeed Limit” fault will occur if the speed reaches [Max Speed] + [Overspeed Limit]. If this condition is unacceptable, action should be taken to 1) limit supply voltages within the specification of the drive and, 2) limit fast positive input voltage changes to less than 10%. Without taking such actions, if this operation is unacceptable, the “adjust freq” portion of the bus regulator function must be disabled (see parameters 161 and 162).
2. Actual deceleration times can be longer than commanded deceleration times. However, a “Decel Inhibit” fault is generated if the drive stops decelerating altogether. If this condition is unacceptable, the “adjust freq” portion of the bus regulator must be disabled (see parameters 161 and 162). In addition, installing a properly sized dynamic brake resistor will provide equal or better performance in most cases.

Important: These faults are not instantaneous. Test results have shown that they can take between 2-12 seconds to occur.

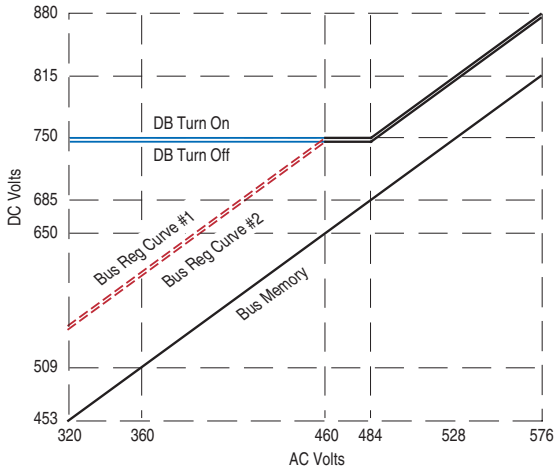
The drive can be programmed for one of five different modes to control the DC bus voltage:

- Disabled
- Adjust Frequency
- Dynamic Braking
- Both with Dynamic Braking first
- Both with Adjust Frequency first

[Bus Reg Mode A], parameter 161 is the mode normally used by the drive unless the “Bus Reg Md B” digital input function is used to switch between modes instantaneously, in which case [Bus Reg Mode B], parameter 162 becomes the active bus regulation mode.

The bus voltage regulation setpoint is determined from bus memory (a means to average DC bus over a period of time). The following tables and figure describe the operation.

Voltage Class	DC Bus Memory	DB On Setpoint	DB Off Setpoint
240	< 342V DC	375V DC	On – 4V DC
	> 342V DC	Memory + 33V DC	
480	< 685V DC	750V DC	On – 8V DC
	> 685V DC	Memory + 65V DC	
600	< 856V DC	937V DC	On – 10V DC
	> 856V DC	Memory + 81V DC	
600/690V PowerFlex 700 Frames 5 & 6 Only	< 983V DC	1076V DC	On – 11V DC
	> 983V DC	Memory + 93V DC	



If [Bus Reg Mode x] is set to “Dynamic Brak”

The Dynamic Brake Regulator is enabled. In “Dynamic Brak” mode the Bus Voltage Regulator is turned off. The “DB Turn On” and turn off curves apply. For example, with a DC Bus Memory at 684V DC, the Dynamic Brake Regulator will turn on at 750V DC and turn back off at 742V DC.

If [Bus Reg Mode x] is set to “Both-Frq 1st”

Both regulators are enabled, and the operating point of the Bus Voltage Regulator is lower than that of the Dynamic Brake Regulator. The Bus Voltage Regulator setpoint follows the “Bus Reg Curve 2” below a DC Bus Memory of 650V DC and follows the “DB Turn Off” curve above a DC Bus Memory of 650V DC (Table C). The Dynamic Brake Regulator follows the “DB Turn On” and turn off curves. For example, with a DC Bus Memory at 684V DC, the Bus Voltage Regulator setpoint is 742V DC and the Dynamic Brake Regulator will turn on at 750V DC and back off at 742V DC.

If [Bus Reg Mode x] is set to “Adjust Freq”

The Bus Voltage Regulator is enabled. The Bus Voltage Regulator setpoint follows “Bus Reg Curve 1” below a DC Bus Memory of 650V DC and follows the “DB Turn On” above a DC Bus Memory of 650V DC (Table C). For example, with a DC Bus Memory at 684V DC, the adjust frequency setpoint is 750V DC.

If [Bus Reg Mode x] is set to “Both-DB 1st”

Both regulators are enabled, and the operating point of the Dynamic Brake Regulator is lower than that of the Bus Voltage Regulator. The Bus Voltage Regulator setpoint follows the “DB Turn On” curve. The Dynamic Brake Regulator follows the “DB Turn On” and turn off curves. For example, with a DC Bus Memory between 650 and 685V DC, the Bus Voltage Regulator setpoint is 758V DC and the Dynamic Brake Regulator will turn on at 742V DC and back off at 734V DC.

Table C

Voltage Class	DC Bus Memory	Bus Reg Curve #1	Bus Reg Curve #2
240	< 325V DC	Memory + 50V DC	Curve 1 – 4V DC
	325V DC ≤ DC Bus Memory ≤ 342V DC	375V DC	
	> 342V DC	Memory + 33V DC	
480	< 650V DC	Memory + 100V DC	Curve 1 – 8V DC
	650V DC ≤ DC Bus Memory ≤ 685V DC	750V DC	
	> 685V DC	Memory + 65V DC	
600	< 813V DC	Memory + 125V DC	Curve 1 – 10V DC
	813V DC ≤ DC Bus Memory ≤ 856V DC	937V DC	
	> 856V DC	Memory + 81V DC	
600/690V PowerFlex 700 Frames 5 & 6 Only	< 933V DC	Memory + 143V DC	Curve 1 – 11V DC
	933V DC ≤ DC Bus Memory ≤ 983V DC	1076V DC	
	> 983V DC	Memory + 93V DC	

Copy Cat

PowerFlex drives have a feature called Copy Cat, which provides a way to upload a complete set of parameters to the LCD HIM. This information can then be used as backup or can be transferred to another drive.

The transfer process manages all conflicts. If a parameter from HIM memory does not exist in the target drive, or the value stored is out of range for the drive, or the parameter cannot be downloaded because the drive is running, the download will stop and a text message will be issued. The remainder of the download can then be aborted or continued by acknowledging the discrepancy. These parameters can then be adjusted manually.

The LCD HIM will store a number of parameter sets (memory dependent) and each individual set can be named.

Current Limit

There are 5 ways that the drive can protect itself from overcurrent or overload situations:

- Hardware Overcurrent - This is a feature that instantly faults the drive if the output current exceeds this value. The value is fixed by hardware and is typically 250% of drive rated amps. The fault code for this feature is F12 “HW Overcurrent.” This feature cannot be defeated or mitigated.
- Software Overcurrent - This protection mode occurs when peak currents do not reach the Hardware Overcurrent value and are sustained long enough and high enough to damage certain drive components. If this situation occurs, the drives protection scheme will cause an F36 “SW Overcurrent” fault. The point at which this fault occurs is fixed and stored in drive memory.
- Software Current Limit - This is a feature that attempts to reduce current by folding back output voltage and frequency if the output current exceeds a programmable value. The [Current Lmt Val] parameter is programmable between approximately 25% and 150% of drive rating. The reaction to exceeding this value is programmable with [Shear Pin Fault]. Enabling this parameter creates an F63 “Shear Pin Fault.” Disabling this parameter causes the drive to use fold back to attempt load reduction.
- Heatsink Temperature Protection - The drive constantly monitors the heatsink temperature. If the temperature exceeds the drive maximum, a “Heatsink OvrTemp” fault will occur. The value is fixed by hardware at a nominal value of 100 degrees C. This fault is generally not used for overcurrent protection due to the thermal time constant of the heatsink. It is an overload protection.
- Drive Overload Protection - Refer to "Drive Overload" on page 39.

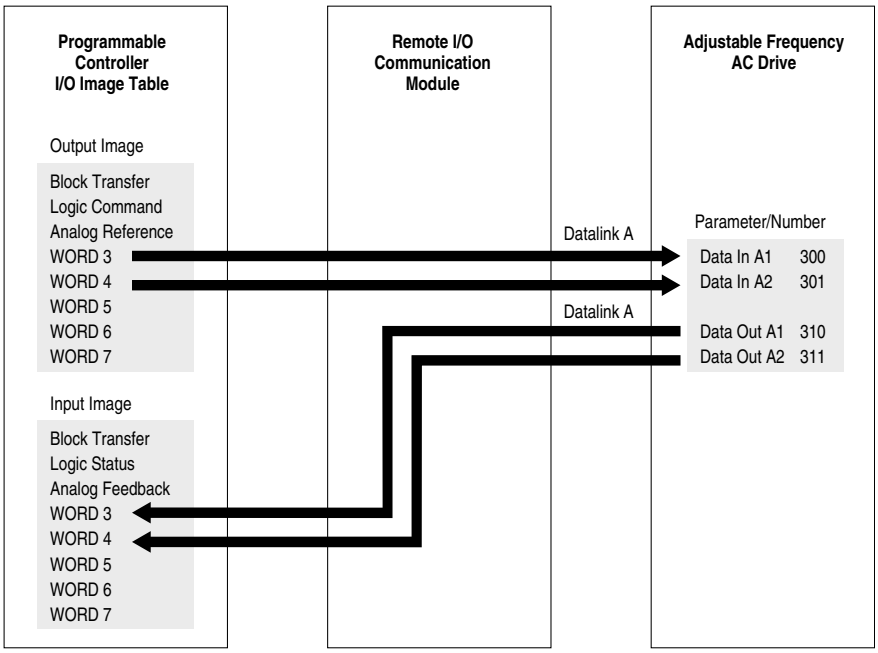
Datalinks

A Datalink is one of the mechanisms used by PowerFlex drives to transfer data to and from a programmable controller. Datalinks allow a parameter value to be changed without using an Explicit Message or Block Transfer. Datalinks consist of a pair of parameters that can be used independently for 16 bit transfers or in conjunction for 32 bit transfers. Because each Datalink consists of a pair of parameters, each Datalink occupies two 16 or 32-bit words in both the input and output image tables, depending on configuration. A parameter number is entered into the Datalink parameter. The value that is in the corresponding output data table word in the controller is then transferred to the parameter whose number has been placed in the Datalink parameter. The following example demonstrates this concept. The object of the example is to change Accel and Decel times “on the fly” under PLC control.

The user makes the following PowerFlex drive parameter settings:
[Data In A1], parameter 300 = 140 (parameter number of [Accel Time 1]
[Data In A2], parameter 301 = 142 (parameter number of [Decel Time 1]

In the PLC data Table, the user enters Word 3 as a value of 100 (10.0 Secs) and word 4 as a value of 133 (13.3 seconds). On each I/O scan, the parameters in the PowerFlex drive are updated with the value from the data table:
[Accel Time], parameter 140 = 10.0 seconds (output image table Word 3 value)
[Decel Time], parameter 142 = 13.3 seconds (output image table Word 4 value).

Any time these values need to be changed, the new values are entered into the data table, and the parameters are updated on the next PLC I/O scan.



Rules for Using Datalinks

- A Datalink consists of 4 words, 2 for Datalink x IN and 2 for Datalink x Out. They cannot be separated or turned on individually.
- Only one communications adapter can use each set of Datalink parameters in a PowerFlex drive. If more than one communications adapter is connected to a single drive, multiple adapters must not try to use the same Datalink.
- Parameter settings in the drive determine the data passed through the Datalink mechanism
- When Datalinks are used to change a value in the drive, the value is not written to the Non-Volatile Storage (EEprom memory). The value is stored in volatile memory (RAM) and lost when the drive loses power.

32-Bit Parameters using 16-Bit Datalinks

To read (and/or write) a 32-bit parameter using 16-bit Datalinks, typically both Datalinks (A,B,C,D) are set to the 32-bit parameter. For example, to read Parameter 09 - [Elapsed MWh], both Datalink A1 and A2 are set to “9.” Datalink A1 will contain the least significant word (LSW) and Datalink A2 the most significant word (MSW). In this example, the parameter 9 value of 5.8MWh is read as a “58” in Datalink A1

Datalink	Most/Least Significant Word	Parameter	Data (decimal)
A1	LSW	9	58
A2	MSW	9	0

Regardless of the Datalink combination, x1 will always contain the LSW and x2 will always contain the MSW.

In the following examples Parameter 242 - [Power Up Marker] contains a value of 88.4541 hours.

Datalink	Most/Least Significant Word	Parameter	Data (decimal)
A1	LSW	242	32573
A2	-Not Used-	0	0

Datalink	Most/Least Significant Word	Parameter	Data (decimal)
A1	-Not Used-	0	0
A2	MSW	242	13

Even if non-consecutive Datalinks are used (in the next example, Datalinks A1 and B2 would not be used), data is still returned in the same way.

Datalink	Most/Least Significant Word	Parameter	Data (decimal)
A2	MSW	242	13
B1	LSW	242	32573

32-bit data is stored in binary as follows:

MSW	2^{31} through 2^{16}
LSW	2^{15} through 2^{0}

Example

Parameter 242 - [Power Up Marker] = 88.4541 hours
MSW = $13_{decimal} = 1101_{binary} = 2^{16} + 2^{18} + 2^{19} = 851968$
LSW = 32573
851968 + 32573 = 884541

DC Bus Voltage / Memory

70EC ✓ 700VC ✓

[DC Bus Voltage] is a measurement of the instantaneous value. [DC Bus Memory] is a heavily filtered value or “average” bus voltage. Just after the pre-charge relay is closed during initial power-up, bus memory is set equal to bus voltage. Thereafter it is updated by ramping at a very slow rate toward the instantaneous bus voltage [DC Bus Voltage]. The filtered value ramps at approximately 2.4V DC per minute (for a 480V AC drive).

Bus memory is used as a comparison value to sense a power loss condition. If the drive enters a power loss state, the bus memory will also be used for recovery (e.g. pre-charge control or inertia ride through upon return of the power source) upon return of the power source. Update of the bus memory is blocked during deceleration to prevent a false high value caused by a regenerative condition.

Digital Inputs

70EC ✓ 700VC ✓

Digital Input Configuration

Inputs are configured for the required function by setting a [Digital Inx Sel] parameter (one for each input). These parameters cannot be changed while the drive is running.

Input Function Detailed Descriptions

- **Stop-Clear Faults**

  An open input will cause the drive to stop and become “not ready”. A closed input will allow the drive to run when given a Start or Run command.

  If “Start” is configured, then “Stop - Clear Faults” must also be configured. Otherwise, a digital input configuration alarm will occur. “Stop - Clear Faults” is an optional setting in all other cases.

  An open to closed transition is interpreted as a Clear Faults request. The drive will clear any existing faults.

  If the “Clear Faults” input function is configured at the same time as “Stop - Clear Faults”, then it will not be possible to reset faults with the “Stop - Clear Faults” input.

- **Run Forward, Run Reverse**

  These settings cause the drive to run and with a specific direction, as long as the configured input is held closed. Also, these “2-wire” settings prevent any other connected device from starting the drive. To use a “2-wire” digital input setting that is compatible with start commands from a communication adapter, see "Run w/Comm" on page 28.

  An open to closed transition on one input or both inputs while the drive is stopped will cause the drive to run unless the “Stop - Clear Faults” input function is configured and open.

  The table below describes the basic action taken by the drive in response to particular states of these input functions.

Run Forward	Run Reverse	Action
Open	Open	Drive stops, terminal block relinquishes direction ownership.
Open	Closed	Drive runs in reverse direction, terminal block takes direction ownership.
Closed	Open	Drive runs in forward direction, terminal block takes direction ownership.
Closed	Closed	Drive continues to run in current direction, but terminal block maintains direction ownership.

  It is not necessary to program both “Run Forward” and “Run Reverse.” These two functions will operate with or without each other.

  Important: Direction control is an “Exclusive Ownership” function (see Owners). This means that only one control device (terminal block, DPI device, HIM, etc.) at a time is allowed to control direction at a time. The terminal block must become direction “owner” before it can be used to control direction. If another device is currently the direction owner (as indicated by [Direction Owner]), **it will not be possible to start the drive or change direction by using the terminal block digital inputs programmed for both Run and Direction control (e.g. Run/Fwd).**

- **Run**

  This setting is similar to “Run Forward” and “Run Reverse” settings. The only difference being that direction is determined by another input or another device’s command (HIM or comm adapter).

- **Run Level, RunFwd Level, and RunRev Level**

  The “non-level” version of these “2-wire” control functions require a rising edge (open to close transition) in order for the drive to run. As long as a separate “Stop” command is not issued, these “level” versions do not require a rising edge, the level alone (no rising edge required) determines whether or not the drive will run.

  Example 1

  A drive is faulted and the “Run Level” input is held closed the entire time. Next, the network issues a “Clear Faults” command or another digital input programmed for “Clear Faults” is closed. The drive will immediately restart as long as the “Run Level” input is closed, even if this input did not get opened and then re-closed.

Example 2

A drive is faulted and the “Run Level” input is held closed the entire time. Next, the network issues a “Stop/Clear Faults” command, or another digital input programmed for “Stop/Clear Faults” is activated, or the “Stop button is pressed on the HIM. The drive will not restart until the “Run Level” input is opened and then re-closed, because the fault clearing method used was combined with a stop command.

Example 3

The drive is stopped by the network issuing a “Stop/Clear Faults” command, or another digital input programmed for “Stop/Clear Faults” being activated, or the “Stop” button being pressed on the HIM. The drive will not restart until the “Run Level” input is opened and then re-closed, because the fault clearing method used was one that is combined with a stop command.

Example 4

The drive is stopped by opening a digital input that is programmed for “Enable.” The Run Level input is held closed the entire time. Next, the Enable input is re-closed. The drive will immediately restart as long as the Run Level input is closed, even if this input did not get opened and then re-closed.

- **Run w/Comm**

  All other “Run” digital input settings prohibit communication devices from starting the drive. “Run w/Comm” allows communication adapters to start the drive even if the digital input “Run w/Comm” is in the open state. In addition, the communication device must have given up its ownership in order for transitions on the “Run w/Comm” digital input to take any action.

- **Start**

  An open to closed transition while the drive is stopped will cause the drive to run in the current direction, unless the “Stop-Clear Faults” input function is open. If “Start” is configured, then “Stop-Clear Faults” must also be configured.

- **Forward/Reverse**

  This function is one of the ways to provide direction control when the “Start” or “Run” functions (not combined with direction) are used.

  An open input sets direction to forward. A closed input sets direction to reverse. If state of input changes and drive is running or jogging, drive will change direction.

- **Jog Forward, Jog Reverse**

  Jog is a non-latched command such as Run, but overrides the normal speed reference and uses [Jog Speed 1].

  An open to closed transition on one input or both inputs while the drive is stopped will cause the drive to jog unless the “Stop - Clear Faults” input function is configured and open. The table below describes the actions taken by the drive in response to various states of these input functions.

Jog Forward	Jog Reverse	Action
Open	Open	Drive will stop if already jogging, but can be started by other means. Terminal block relinquishes direction ownership.
Open	Closed	Drive jogs in reverse direction. Terminal block takes direction ownership.
Closed	Open	Drive jogs in forward direction. Terminal block takes direction ownership.
Closed	Closed	Drive continues to jog in current direction, but terminal block maintains direction ownership.

The drive will not jog while the drive is running or while the “Stop-Clear Faults” input is open. **Start has precedence.**

ATTENTION: If a normal drive start command is received while the drive is jogging, the drive will switch from jog mode to run mode. The drive will not stop, but may change speed and/or change direction.

Important: Direction control is an “Exclusive Ownership” function (see Owners). This means that only one control device (terminal block, DPI device, HIM, etc.) at a time is allowed to control direction at a time. The terminal block must become direction “owner” before it can be used to control direction. If another device is currently the direction owner (as indicated by [Direction Owner]), **it will not be possible to jog the drive or change direction by using the terminal block digital inputs programmed for both Run and Direction control (e.g. Run/Fwd).**

If another device is not currently the direction owner (as indicated by [Direction Owner]) and the terminal block bit is set in the [Direction Mask] and [Logic Mask] parameters, the terminal block becomes direction owner as soon as one (or both) of the “Jog Forward” or “Jog Reverse” input functions is closed.

- **Jog 1, Jog 2**

  These settings are similar to “Jog Forward” and “Jog Reverse” with the only difference being that direction is determined by another input or another device’s command (HIM or comm adapter). In addition, these settings will use either [Jog Speed 1] or [Jog Speed 2], respectively. In unipolar mode, the absolute value will be used along with a separate direction command. In bipolar mode, the polarity of [Jog Speed 1] or [Jog Speed 2] will determine the direction of jog.

- **Speed Select 1, 2, and 3**

  Up to three digital inputs can be used to select the speed reference. The open/closed state of all speed select input functions combine to select which source is the speed reference. Refer to "Speed Reference" on page 98.

- **Auto/Manual**

  Refer to "Auto/Manual" on page 13. The Auto/Manual setting for a digital input works in conjunction with the overall Auto/Manual function. When this input is closed, it overrides other speed references, but only if another device (HIM) did not have ownership of the Manual state. If the digital input is successful in gaining manual control, the speed reference comes from [TB Man Ref Sel], which can be set to any of the analog inputs.

- **Accel 2, Decel 2**

  These digital input functions toggle between primary and secondary ramp rates. For example, with a digital input programmed for Accel 2, an open digital input follows [Accel Time 1]. A closed digital input follows [Accel Time 2].

- **Acc2 & Dec2**

  This setting is similar to the Accel 2 and Decel 2 settings, except that one digital input will toggle both Accel and Decel at the same time.

- **MOP Increment, MOP Decrement**

  These functions are used to increment and decrement the Motor Operated Potentiometer (MOP) value inside the drive. The MOP is a reference value that can be incremented and decremented by external devices. The MOP value will be retained through a power cycle.

  In order for the drive to use the MOP value as the current speed reference, either [Speed Ref A Sel] or [Speed Ref B Sel] must be set to “MOP.” Refer to "MOP" on page 50.

- **Stop Mode B**

  This digital input function selects between two different drive stop modes. See also "Stop Modes" on page 109.

  If the input is open, then [Stop Mode A] selects which stop mode to use. If the input is closed, then [Stop Mode B] selects which stop mode to use. If this input function is not configured, then [Stop Mode A] always selects which stop mode to use.

- **Bus Regulation Mode B**

  This digital input function selects how the drive will regulate excess voltage on the DC bus. See also Bus Regulation.

  If the input is open, then [Bus Reg Mode A] selects which bus regulation mode to use. If the input is closed, then [Bus Reg Mode B] selects which bus regulation mode to use. If this input function is not configured, then [Bus Reg Mode A] always selects which bus regulation mode to use.

- **PI Enable**

  If this input function is closed and [PI Control], bit 0 = “enabled”, the operation of the Process PI loop will be enabled.

  If this input function is open, the operation of the Process PI loop will be disabled. See "Process PID Loop" on page 77.

- **PI Hold**

  If this input function is closed, the integrator for the Process PI loop will be held at the current value.

  If this input function is open, the integrator for the Process PI loop will be allowed to increase. See "Process PID Loop" on page 77.

- **PI Invert**

  If this input function is closed, the PI Error is inverted. If this input function is open, the PI Error is not inverted.

- **PI Reset**

  If this input function is closed, the integrator for the Process PI loop will be reset to 0.

  If this input function is open, the integrator for the Process PI loop will integrate normally. See "Process PID Loop" on page 77.

- **Auxiliary Fault**

  This input function is normally closed and allows external equipment to fault the drive. When this input opens, the drive will fault with the “Auxiliary Input” (F2) fault code. If this input function is not configured, then the fault will not occur.

- **Local Control**

  This input function allows exclusive control of all drive logic functions from the terminal block. If it is closed, the terminal block has exclusive control (disabling all the DPI devices) of drive logic, including start, reference selection, acceleration rate selection, etc. The exception is the stop condition, which can always be asserted from any connected control device.

  The drive must be stopped and other devices must not own exclusive control in order for the terminal block to gain complete local control.

- **Clear Faults**

  The “Clear Faults” digital input function allows an external device to reset drive faults through the terminal block. An open to closed transition on this input will cause an active fault (if any) to be reset.

  If this input is configured at the same time as “Stop - Clear Faults”, then only the “Clear Faults” input can cause faults to be reset.

- **Enable**

  Closing this input allows the drive to run when a Start command is issued.

  If the drive is already running when this input is opened, the drive will coast and indicate “not enabled” on the HIM (if present). This is not considered a fault condition, and no fault will be generated.

  If this function is not configured, the drive is considered enabled. If multiple “Enable” inputs are configured, then the drive will not run if any of the inputs are open.

  Any of the digital inputs can be configured as “Enable.” However, Digital Input 6 can be configured as a “Dedicated Hardware Enable” by removing a jumper. In this case the parameter setting for [Digital In6 Sel] has no effect. This hardware configuration bypasses software processing of the enable function and provides hardware protection against a drive run condition. Refer to the User Manual for jumper locations.

- **Exclusive Link**

  This function is used for exclusively controlling a digital output by activating a digital input. It is used when no other functionality s desired for the input. See Digital Outputs.

  The state of any digital input can be “passed through” to a digital output by setting the value of a digital output configuration parameter ([Digital Out*x* Sel]) to “Input *n* Link”. The output will then be controlled by the state of the input, even if the input is being used for a second function. If the input is configured as “Not used” input function, the link to the input is considered non-functional.

- **Power Loss Level** **700VC ONLY**

  When the DC bus level in the drive falls below a certain level, a “power loss” condition is created in the drive logic. This function allows the user to select between two different “power loss” detection levels.

  If the input is closed, the drive will take its power loss level from [Power Loss Level]. If the input is open, the drive will use a power loss level designated by internal drive memory, typically 82% of nominal.

  If the input function is not configured, then the drive always uses the internal power loss level.

- **Precharge Enable**

  This function is used to manage disconnection from a common DC bus.

  If the input is closed, this indicates that the drive is connected to common DC bus and normal precharge handling can occur, and that the drive can run (start permissive). If the physical input is open, this indicates that the drive is disconnected from the common DC bus, and thus the drive should enter the precharge state and initiate a coast stop immediately in order to prepare for reconnection to the bus.

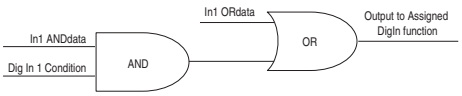
  If this input function is not configured, then the drive assumes that it is always connected to the DC bus, and no special precharge handling will be done.

- **Digital Input Data Logic**

  Digital Input Data Logic performs logical operations on the condition of digital inputs with that of data contained in a parameter. The output of the logical operation performs the function (start, stop, preset speed, etc.) that is “assigned” to the digital input. An example of an appropriate application for this function is the temporary override of a conveyor sensor that is wired directly to a digital input. In such a case, a controller could write the data to the drive over a network to start a drive, and then reset the data after the conveyor load clears the sensor, thus allowing the sensor to stop the next load.

  When this feature is enabled through bit 9 (“DigIn DatLog”) of [Compensation], parameter 56, the operation is performed. If the feature is disabled, the functions assigned to the digital inputs will operate directly, regardless of the data in the “Digital Input Data Logic” parameter.

  The following diagram shows the logical operation. The condition of each digital input is “ANDed” with the “ANDdata” from [DigIn DataLogic], parameter 411, then “ORed” with the “ORdata” from [DigIn DataLogic]. The result is fed to the assigned digital input function.



  The logical result (output) for each string of operations for a digital input can be viewed in the upper half of parameter 216 [Dig In Status].

  When the feature is enabled, and the Input 6 Dedicated Enable Jumper is pulled, the Data Logic function will still be performed on input 6, but will not interfere with the dedicated hardware path to the gate drive circuit.

- **Fast Stop**

  When this input is opened, the drive performs a “Fast Stop.” See "Stop Modes" on page 109 for a description of this stopping method.

- **Speed/Torque Select 1, 2, and 3**

  These settings provide the ability to switch between different speed/torque modes from digital input combinations. See "Speed/Torque Mode" on page 105 for a complete description of these modes and the digital input combinations that activate each mode.

- **User Set Select 1 and 2**

These settings are used in the “dynamic mode” of user sets, which provides switching between entire parameter sets from digital input combinations. See "User Sets" on page 114 for a complete description of these modes and the digital input combinations that activate each mode.

Digital Input Conflict Alarms

If the user configures the digital inputs so that one or more selections conflict with each other, one of the digital input configuration alarms will be asserted**. As long as the Digital Input Conflict exists, the drive will not start.** These alarms will be automatically cleared by the drive as soon as the parameters are changed to remove the conflicts.

Examples of configurations that cause an alarm are:

- Configuring both the “Start” input function and the “Run Forward” input function at the same time. “Start” is only used in “3-wire” start mode, and “Run Forward” is only used in “2-wire” run mode, so they should never be configured at the same time
- Configuring the same toggle input function (for instance “Forward/Reverse”) to more than one physical digital input simultaneously.

These alarms, called Type 2 Alarms, are different from other alarms in that it will not be possible to start the drive while the alarm is active. It should not be possible for any of these alarms to occur while the drive is running, because all digital input configuration parameters can only be changed while the drive is stopped. Whenever one or more of these alarms is present, the drive ready status will become “not ready” and the HIM will reflect a conflict message. In addition, the drive status light will be flashing yellow. Refer to the User Manual for a complete list of Type 2 Alarms.

Digital Outputs

Each digital output can be programmed to change state based on one of many different conditions. These conditions fall into different categories as follows:

- Drive Status Conditions (e.g. fault, reverse, etc.).
- Exceeded Levels (e.g. current, frequency, etc.)
- Controlled by a Digital Input.
- Controlled by the Network.

1. Drive Status Conditions

Condition	Description
Fault	A drive Fault has occurred and stopped the drive
Alarm	A Drive Type 1 or Type 2 Alarm condition exists
Ready	The drive is powered, Enabled and no Start Inhibits exist. It is “ready” to run
Run	The drive is outputting Voltage and frequency to the motor (indicates 3–wire control, either direction)
Forward Run	The drive is outputting Voltage and frequency to the motor (indicates 2–wire control in Forward)
Reverse Run	The drive is outputting Voltage and frequency to the motor (indicates 2–wire control in Reverse)
Auto Restart	The drive is currently attempting the routine to clear a fault and restart the drive
Powerup Run	The drive is currently executing the Auto Restart or “Run at Power Up” function
DC Braking	The drive is currently executing either a “DC Brake” or a “Ramp to Hold” Stop command and the DC braking voltage is still being applied to the motor.
Current Limit	The drive is currently limiting output current

Condition	Description
Economize	The drive is currently reducing the output voltage to the motor to attempt to reduce energy costs during a lightly loaded situation.
Motor Overld	The drive output current has exceeded the programmed [Motor NP FLA] and the electronic motor overload function is accumulating towards an eventual trip.
Power Loss	The drive has monitored DC bus voltage and sensed a loss of input AC power that caused the DC bus voltage to fall below the fixed monitoring value (82% of [DC bus Memory]
PI Enabled	The drive's process PID controller has been enabled (see "Process PID").
PI Hold	The process PID integrator is being held (see "Process PID").
Drive Overld	The drive is in a overload condition and will take action to avoid a fault, or possibly fault if the load is not reduced (see "Drive Overload").

Digital Out Mask Function

This feature provides a method for one of the digital outputs to change state based on monitoring of individual parameter bits. An AND or OR function can be chosen to determine the output result, based on the state of more than one bit in the selected source parameter.

Configuration

Parameters 380, 384, 388 [Digital Outx Sel] applies the mask function to the selected value in Parameter 393 [Dig Out Param]. A value of 31 chooses "Mask 1 AND" and a value of 32 chooses "Mask 1 OR". Note: there is only one parameter (P393) that can feed this function with data and only 1 parameter (P394) than can mask the data. However, each digital output can apply either the AND function or the OR function to the result before it takes action on a digital output. The choices for parameter 393 are shown in the User Manual.

While monitoring the value of a particular choice for Parameter 393 [Dig Out Param], only the bits with a corresponding value of "1" in Parameter 394 [Dig Out Mask], will be monitored and passed through to the AND or OR digital output functions. All of the bits with zeros in the mask are ignored.

Example

This example demonstrates how to turn on a digital output if dynamic braking is occurring (the dynamic brake transistor is switching) and bus frequency regulation is also occurring. This would be an indication that the connected brake resistor is shunting energy, but there is too much regeneration for that moment in time and the drive is not following its commanded decel rate.

- P393 [Dig Out Param] = "Drive Sts 2"
- P380 [Digital Out 1 Sel] = "Mask 1 AND"
- P394 [Dig Out Mask] = 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0

Setting bits 7 and 11 of [Dig Out Mask] equal to 1 allows bit 7 ("DB Active") and bit 11 ("Bus Freq Reg") of [Drive Status 2]) to pass through to the AND function. This way, when both of these conditions occur together, the digital output will turn on.

2. Exceeded Levels

These functions require a level to be programmed into [Dig Out1 Level] and/or [Dig Out2 Level] depending on the output(s) being used. If the value for the specified function (frequency, current, etc.) exceeds the programmed limit, the output will activate. If the value falls back below the limit, the output will deactivate.

Notice that the [Dig Outx Level] parameters do not have units. The drive assumes the units from the selected function. For example, if the selection is current, the drive assumes that the value for [Dig Outx Level] is % rated Amps. If the selection is Temperature, the drive assumes that the value for [Dig Outx

Level] is degrees C. No units will be displayed on HIMs, offline tools, devices communicating over a network, PLC's, etc.

The minimum and maximum value for [Dig Outx Level] is independent of the selection for [Dig Outx Sel].

The following values can be annunciated

Value	Description
At Freq	The drive output frequency equals or exceeds the programmed Limit
At Current	The drive total output current exceeds the programmed Limit
At Speed	The drive Output Frequency has equalled the commanded frequency
At Torque	The drive output torque current component exceeds the programmed Limit
At Temp	The drive operating temperature exceeds the programmed Limit
At Bus Volts	The drive bus voltage exceeds the programmed Limit
At PI Error	The drive Process PI Loop error exceeds the programmed Limit

3. Controlled by Digital Input

A digital output can be "linked" directly to a digital input. When the input is closed, the output will be energized, and when the input is open, the output will be de-energized. This "linking" will occur if two conditions exist:

– The Input is configured for any choice other than "Unused"

– The Output is configured for the appropriate "Input x Link"

Note that the output will be controlled by the state of the input, even if the input has been assigned a normal function (e.g. Start, Jog)

See "Exclusive Link" on page 31. This selection provides a way to connect the input to the output without the output being used for another function. Note: the output still must be set for "Input x Link."

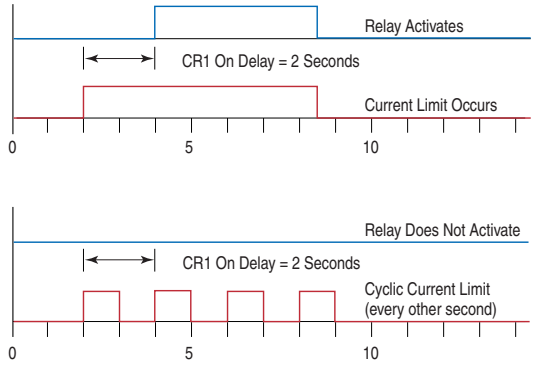
Digital Output Timers

Each digital output has two programmable timers.

The "On Time" specifies the delay between the appearance of the programmed condition and the corresponding digital output change of state.

The "Off Time" specifies the delay between the appearance of the programmed condition and the corresponding digital output change of state.

If a transition on an output condition occurs and starts a timer, and the output condition goes back to its original state before the timer runs out, then the timer will be aborted and the corresponding digital output will not change state.



4. **Controlled by the Network**

   This configuration is used when it is desired to control the digital outputs over network communications instead of a drive related function. In this case, [Digital Out x Sel] is set to “Param Cntl,” in which case the bit value of [DigOut Setpt], parameter 379 energizes the respective digital output. Bit 0 corresponds to output 1. Bit 1 corresponds to output 2, and so on. To complete the configuration for control over a network, a datalink must be established with [Digital Out Setpt], parameter 379.

   Example

   Digital Output 2 controlled by Data In B1.

   Setup
   - [Data In B1], parameter 302 = 379 ([Dig Out Setpt] as the Data In target)
   - [Digital Out2 Sel], parameter 384 = 30 “Param Cntl”

   When Bit 1 of Data In B1 =1 Digital Out 2 will be energized.

Direction Control

Direction control of the drive is an exclusive ownership function. Only one device can command direction at a time. Direction is defined as the forward (+) or reverse (–) control of the drive output frequency, not motor rotation. Motor wiring and phasing determines its CW or CCW rotation. Direction of the drive is controlled in one of four ways:

1. 2-Wire digital input selection such as Run Forward or Run Reverse.
2. 3-Wire digital input selection such as Forward/Reverse, Forward or Reverse.
3. Control Word bit manipulation from a DPI device such as a communications interface. Bits 4 & 5 control direction. Refer to the *Logic Command Word* information in Appendix A of the PowerFlex 70 or 700 User Manual.
4. The sign (+/-) of a reference signal, such as a bipolar analog input or the 16th bit of a network reference.

Direction commands by various devices can be controlled using the [Direction Mask]. See page 49 for details on masks.

Refer to "Digital Inputs" on page 26 and "Analog Inputs" on page 4 for more detail on the configuration and operating rules for direction control.

DPI

Drive Peripheral Interface (DPI) is a CAN based, Master-Slave protocol, created to provide a standard way of connecting motor control products and optional peripheral devices together. It allows multiple (up to 6) devices to communicate with a motor control product without requiring configuration of the peripheral. DPI provides two basic message types called Client/Server (C/S) and Producer/Consumer (P/C). Client/Server messages are used to transfer parameter and configuration information in the background (relative to other message types). Producer/Consumer messages are used for control and status information. Multiple devices can be attached to and communicate with drives at the same time. This communication interface is the primary way to interact with, and control the drive.

Important: The PowerFlex 700 Vector Control option only supports the DPI communication protocol. It will not communicate with SCANport peripheral devices (previous generation HIM and communication adapters).

Client/Server Operation

Client/Server messages operate in the background (relative to other message types) and are used for non-control purposes. The Client/Server messages are based on a 10ms “ping” event that allows peripherals to perform a single transaction (e.g. one C/S transaction per peripheral per time period). Message fragmentation (because the message transaction is larger than the standard CAN message of eight data bytes) is automatically handled by Client/Server operation. The following types of messaging are covered:

- Logging in peripheral devices
- Read/Write of parameter values
- Access to all parameter information (limits, scaling, default, etc.)
- User set access
- Fault/Alarm queue access
- Event notification (fault, alarm, etc.)
- Access to all drive classes/objects (e.g. Device, Peripheral, Parameter, etc.)

Producer/Consumer Operation

Producer/Consumer messages operate at a higher priority than Client/Server messages and are used to control/report the operation of the drive (e.g. start, stop, etc.). A P/C status message is transmitted every 5ms (by the drive) and a command message is received from every change of state in any attached DPI peripheral. Change of state is a button being pressed or error detected by a DPI peripheral. SCANport devices are slightly different in that those peripherals transmit command messages upon reception of a drive status message rather than on detection of a change of state. Producer/Consumer messages are of fixed size, so support of message fragmentation is not required. The following types of messaging are covered:

- Drive status (running, faulted, etc.)
- Drive commands (start, stop, logic parsing, etc.)
- Entering Flash programming mode
- “Soft” login and logout of peripheral devices (enabling/disabling of peripheral control)

Peer-to-Peer operation

Peer-to-Peer messaging allows two devices to communicate directly rather than through the master or host (e.g. drive). They are the same priority as C/S messages and will occur in the background. If an LCD HIM is attached, it will be able to directly access peripheral parameters (e.g. communication adapter parameters) using Peer-to-Peer messages.

Peripheral devices will be scanned at a 10ms rate. Drive status messages will be produced at a 5ms rate, while peripheral command messages will be accepted (by the drive) as they occur (e.g. change of state). Based on these timings, the following worst case conditions can occur (independent of the baud rate and protocol):

- Change of peripheral state (e.g. Start, Stop, etc.) to change in the drive – 10ms
- Change in reference value to change in drive operation – 10ms
- Change in Datalink data value to change in the drive – 10ms
- Change of parameter value into drive – 20ms times the number of attached peripherals

The maximum time to detect the loss of communication from a peripheral device is 500ms.

Table D Timing specifications contained in DPI and SCANport

DPI	Host status messages only go out to peripherals once they log in and at least every 125ms (to all attached peripherals). Peripherals time out if >250ms. Actual time is dependent on number of peripherals attached. Minimum time goal is 5ms (may have to be dependent on Port Baud Rate). DPI allows minimum 5ms status at 125k and 1ms status at 500k.
SCANport	Host status messages only go out to peripherals once they log in. Peripherals time out if >500ms. If Peripheral receives incorrect status message type, Peripheral generates an error. Actual time is dependent on number of peripherals attached. SCANport allows minimum rate of 5ms.
DPI	Host determines MUT based on number of attached peripherals. Range of values from 2 to 125ms. Minimum goal time is 5ms. DPI allows 2ms min at 500k and 5ms min at 125k.
SCANport	No MUT.
DPI	Peripheral command messages (including Datalinks) are generated on change-of-state, but not faster than Host MUT and at least every 250ms. Host will time out if >500ms.
SCANport	Command messages are produced as a result of Host status message. If no command response to Host status within 3 status scan times, Host will time out on that peripheral.
DPI	Peer message requests cannot be sent any faster than 2x of MUT.
SCANport	No Peer message support
DPI	Host must ping every port at least one every 2 sec. Peripherals time out if >3 sec. Host will wait maximum of 10ms (125k) or 5ms (500k) for peripheral response to ping. Peripherals typical response time is 1ms. Peripherals only allow one pending explicit message (e.g. ping response or peer request) at a time.
SCANport	Host waits at least 10ms for response to ping. Host cannot send more than 2 event messages (including ping) to a peripheral within 5ms. Peripherals typical response time is 1ms.
DPI	Response to an explicit request or fragment must occur within 1 sec or device will time out (applies to Host or Peripheral). Time-out implies retry from beginning. Maximum number of fragments per transaction is 16. Flash memory is exception with 22 fragments allowed.
SCANport	Assume same 1 sec time-out. Maximum number of fragments is 16
DPI	During Flash mode, host stops ping, but still supports status/command messages at a 1 – 5 sec rate. Drive will use 1 sec rate. Data transfer occurs via explicit message as fast as possible (e.g. peripheral request, host response, peripheral request, etc.) but only between two devices.
SCANport	No Flash mode support

The Minimum Update Time (MUT), is based on the message type only. A standard command and Datalink command could be transmitted from the same peripheral faster than the MUT and still be O.K. Two successive Datalink commands or standard commands will still have to be separated by the MUT, however.

DriveGuard

Refer to "*DriveGuard Safe-Off User Manual*" publication PFLEX-UM001.

Drive Overload

The drive overload function has two separate protection schemes, an inverse time protection based on current, and thermal manager based on measured power module temperature and operating conditions. The drive may fold back current limit when either of these methods detects a problem.

Any protection for the motor and associated wiring is provided by a Motor Thermal Overload feature.

The drive will monitor the temperature of the power module based on a measured temperature and a thermal model of the power module. As the temperature rises the drive may lower the PWM frequency to decrease the switching losses in the power module. If the temperature continues to rise, the drive may reduce current limit to try to decrease the load on the drive. If the drive temperature becomes critical, the drive will generate a fault.

If the drive is operated in a low ambient condition the drive may exceed rated levels of current before the monitored temperature becomes critical. To guard against this situation the drive thermal overload also includes an inverse time algorithm. When this scheme detects operation beyond rated levels, current limit may be reduced or a fault may be generated.

Normal Duty and Heavy Duty Operation

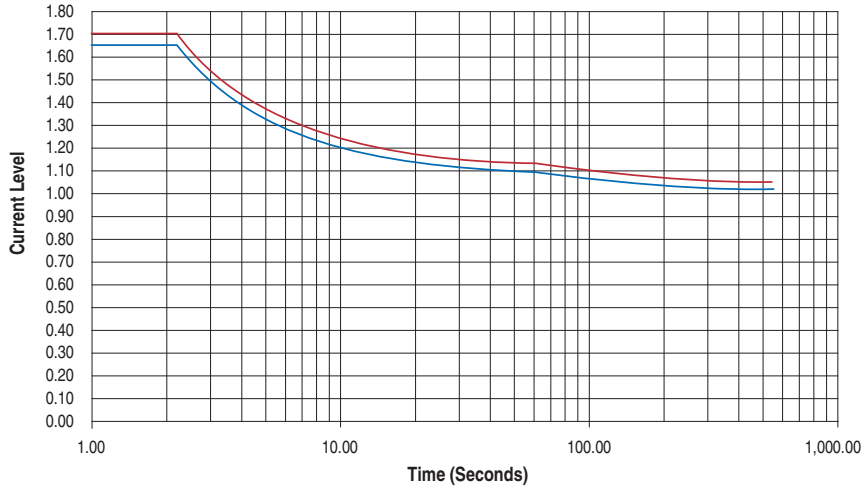
Applications require different amounts of overload current. Sizing a drive for Normal Duty provides 110% for 60 seconds and 150% for 3 seconds. For a heavy duty application, one larger rating of a drive is used (in comparison to the motor), and therefore provides a larger amount of overload current in comparison to the motor rating. Heavy duty sizing will provide at least 150% for 60 seconds and 200% for 3 seconds. These percentages are with respect to the connected motor rating.

Inverse Time Protection

The lower curve in Figure 2 shows the boundary of normal-duty operation, where the drive is rated to produce 110% of rated current for 60 seconds, 150% of rated current for three seconds, and 165% of rated current for 100 milliseconds. The maximum value for current limit is 150% so the limit of 165% for 100 milliseconds should never be crossed. If the load on the drive exceeds the level of current as shown on the upper curve, current limit may fold back to 100% of the drive rating until the 10/90 or 5/95 duty cycle has been achieved. For example, 60 seconds at 110% will be followed by 9 minutes at 100%, and 3 seconds at 150% will be followed by 57 seconds at 100%. With the threshold for where to take action slightly above the rated level the drive will only fold back when drive ratings are exceeded.

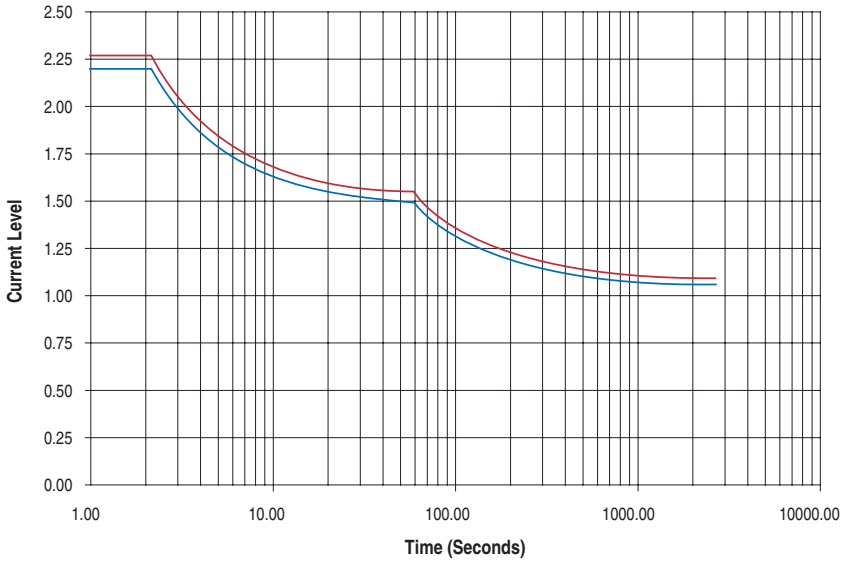
If fold back of current limit is not enabled in [Drive OL Mode], the drive will generate a F64 Drive Overload fault when operation exceeds the rated levels.

Figure 2 Normal Duty Boundary of Operation



Heavy Duty operation follows the same algorithm as Normal Duty, but allows a larger percentage of rated current (one size smaller motor). The percentages are 150% for 60 seconds, 200% for 3 seconds and 220% for 100 milliseconds (see "Normal Duty and Heavy Duty Operation" on page 39.

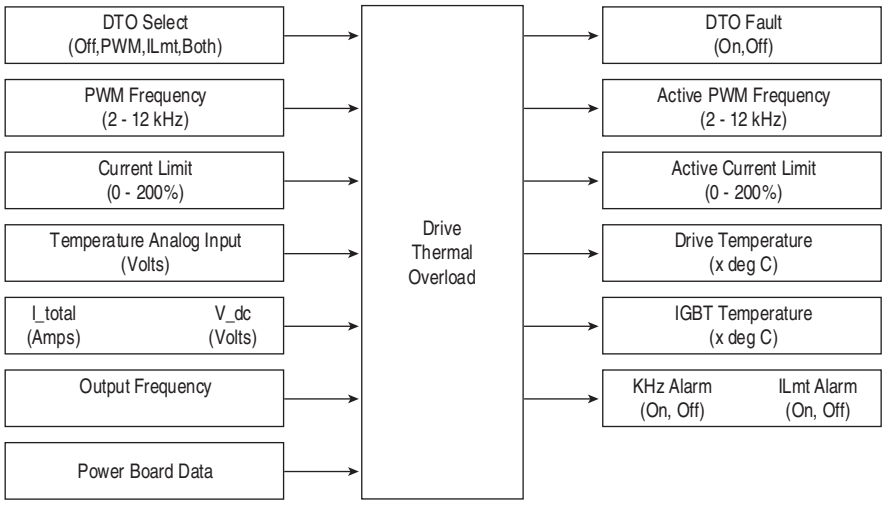
Figure 3 Heavy Duty Boundary of Operation



Thermal Manager

The thermal manager assures that the thermal ratings of the power module are not exceeded. The operation of the thermal manager can be thought of as a function block with the inputs and outputs as shown below.

Figure 4 Thermal Manager Inputs/Outputs



The following is a generalization of the calculations done by the thermal manager. The IGBT junction temperature T_J is calculated based on the measured drive temperature T_{Drive}, and a temperature rise that is a function of operating conditions. When the calculated junction temperature reaches a maximum limit the drive will generate a fault. This fault cannot be disabled. This maximum junction temperature is stored on the power board along with other information to define the operation of the drive overload function. These values are not user adjustable. In addition to the maximum junction temperature, there are thresholds that select the point at which the PWM frequency begins to fold back, and the point at which current limit begins to fold back.

Alarm bits within [Drive Alarm 1] provide status as to when the fold back points are being reached (regardless of whether or not the drive is configured to fold back or not).

“Drv OL Lvl 1” is the alarm bit for PWM fold back. “Drv OL Lvl 2” is the alarm bit for current limit fold back.

Configuration

The [Drive OL Mode] allows the user to select the action(s) to perform with increased current or drive temperature. When this parameter is “Disabled,” the drive will not modify the PWM frequency or current limit. When set to “Reduce PWM” the drive will only modify the PWM frequency. “Reduce CLim” will only modify the current limit. Setting this parameter to “Both-PWM 1st” the drive will modify the PWM frequency first and then the current limit if necessary, to keep the drive from faulting with a Drive Overload or Overtemperature fault.

Temperature Display

The Drive’s temperature is measured (NTC in the IGBT module) and displayed as a percentage of drive thermal capacity in [Drive Temp]. This parameter is normalized to the thermal capacity of the drive (frame dependent) and displays thermal usage in % of maximum (100% = drive Trip). A test point, “Heatsink temperature” is available to read temperature directly in degrees C, but cannot be related to the trip point since “maximums” are only given in %.

Low Speed Operation

When operation is below 4 Hz, the IGBT duty cycle is such that heat will build up rapidly in the device. The thermal manager will increase the calculated IGBT temperature at low output frequencies and will cause corrective action to take place sooner.

When the drive is in current limit the output frequency is reduced to try to reduce the load. This works fine for a variable torque load, but for a constant torque load reducing the output frequency does not lower the current (load). Lowering current limit on a CT load will push the drive down to a region where the thermal issue becomes worse. In this situation the thermal manager will increase the calculated losses in the power module to track the worst case IGBT. For example, if the thermal manager normally provides 150% for 3 seconds at high speeds, it may only provide 150% for one second before generating a fault at low speeds.

Some applications may benefit from the disabling of current limit fold back.

Droop

Droop is used to “shed” load and is usually used when a soft coupling of two motors is present in an application. The master drive speed regulates and the follower uses droop so it does not oppose the master. The input to the droop block is the commanded motor torque. The output of the droop block reduces the speed reference. [Droop RPM @ FLA] sets the amount of speed, in RPM, that the speed reference is reduced when at full load torque. For example, when [Droop RPM @ FLA] is set to 50 RPM and the drive is running at 100% rated motor torque, the droop block would subtract 50 RPM from the speed reference.

Faults

Faults are conditions occurring within and/or outside of the drive. These conditions are (by default) considered to be important enough that drive operation is discontinued. Faults are annunciated via the HIM, communications and/or digital outputs.

Once a fault occurs, it is latched, requiring a fault reset action. If the condition that caused fault still exists when the fault is reset, the drive will fault again and the fault will be latched again.

When a Fault Occurs

1. The drive is set as faulted, causing the drive output to be immediately disabled and a “coast to stop” sequence to occur
2. The fault code is entered into the first buffer of the fault queue (see “Fault Queue” below for rules).
3. Additional data on the status of the drive at the time that the fault occurred is recorded. Note that there is only a single copy of this information which is always related to the most recent fault queue entry [Fault 1 Code], parameter 243. When another fault occurs, this data is overwritten with the new fault data. The following data/conditions are captured and latched into non-volatile drive memory:
   - [Status 1 @ Fault] - drive condition at the time of the fault.
   - [Status 2 @ Fault] - drive condition at the time of the fault.
   - [Alarm 1 @ Fault], - alarm condition at the time of the fault.
   - [Alarm 2 @ Fault] - alarm conditions at the time of the fault.
   - [Fault Amps] - output amps at time of fault.
   - [Fault Bus Volts] - DC Bus volts at time of fault.
   - [Fault Frequency] or [Fault Speed] - drive output frequency (or speed) at time of fault.

Fault Queue

Faults are also logged into a fault queue such that a history of the most recent fault events is retained. Each recorded event includes a fault code (with associated text) and a fault time of occurrence.

A fault queue will record the occurrence of each fault event that occurs while no other fault is latched. A new fault event will not be logged to the fault queue if a previous fault has already occurred, but has not yet been reset. Only faults that actually trip the drive will be logged. A fault that occurs while the drive is already faulted will be not be logged.

The fault queue is a first-in, first-out (FIFO) queue. Fault queue entry #1 will always be the most-recent entry (newest). As new faults are logged, existing entries will be shifted up by one. If the queue is full when a fault occurs, the oldest entry will be discarded.

The fault queue will be saved in nonvolatile storage at power loss, thus retaining its contents through a power off-on cycle.

Fault Code/Text [Fault Code x]

The fault code for each entry can be read in its respective read-only parameter. When viewed with a HIM, only the fault code (not text) is displayed. If viewed via a DPI peripheral (communications network), the queue is not accessed through parameters, and a text string of up to 16 characters is also available.

Fault Time [Fault x Time]

The drive has an internal drive-under-power timer that increments in value over the life of the drive and is saved in nonvolatile storage. Each time the drive is powered down and then repowered, the value of this timer is written to [Power Up Marker], parameter 242.

The time is presented in xxx.yyyy hours (4 decimal places). Internally it will be accumulated in a 32-bit unsigned integer with a resolution of 0.35 seconds, resulting in a rollover to zero every 47.66 years.

The time stamp value recorded in the fault queue at the time of a fault is the value of internal drive under power timer. By comparing this value to the [PowerUp Marker], it is possible to determine when the fault occurred relative to the last drive power-up.

Power Up Marker

This is a copy of the factory "drive under power" timer at the most recent power-up of the drive. It is used to provide relevance of [Fault x Time] values with respect to the power-up of the drive.

Resetting or Clearing a Fault

A latched fault condition can be cleared by the following:

1. An off to on transition on a digital input configured for fault reset or stop/reset.
2. Setting [Fault Clear] to "1."
3. A DPI peripheral (several ways).
4. Performing a reset to factory defaults via parameter write.
5. Cycling power to the drive such that the control board goes through a power-up sequence.

Resetting faults will clear the faulted status indication. If any fault condition still exists, the fault will relatch and another entry made in the fault queue.

Clearing the Fault Queue

Performing a fault reset does not clear the fault queue. This can be done from a menu selection of the HIM or from a DPI command through the communications port.

Fault Configuration

The drive can be configured such that some conditions do not trip the drive.

[Fault Config 1] is a 16 bit parameter enabling or disabling specific fault conditions (see below).

Following is a brief list of each configurable fault. Some of these faults are explained in more detail in their own section of this document.

Bit	Fault Description
0	Power Loss
1	Undervoltage
2	Reserved
3	Motor Overload
4	Shear Pin
5	Auto Restart Tries
6	Decel Inhibit
7	Motor Thermistor
8	Input Phase Loss
9	Load Loss
10	Reserved
11	Shear Pin No Accel
12	Output Phase Loss
13	PTC Hardware

Flux Braking

Flux braking is used to provide extra braking capability without the use of a brake resistor, by taking advantage of the losses in a motor. Flux braking can be used not only to brake a load to a complete stop, but also to brake a load from one speed to a lesser speed. For a complete list of methods that will bring the load to a complete stop, see "Stop Modes" on page 109.

To enable flux braking:

1. [Bus Reg Mode A, B] must be set to “1” Adjust Freq to enable the bus regulator.
2. [Flux Braking] must be set to 1 “Enabled”.

When enabled, flux braking automatically increases the motor flux resulting in an increase of motor losses, but only when braking is required. In general, the flux current is not increased when the motor is at or above rated speed. At higher speeds, field weakening is active and the motor flux current cannot be increased.

Because flux braking increases motor losses, the duty cycle used with this method must be limited. Check with the motor vendor for flux braking or DC braking application guidelines. Also consider using external motor thermal protection.

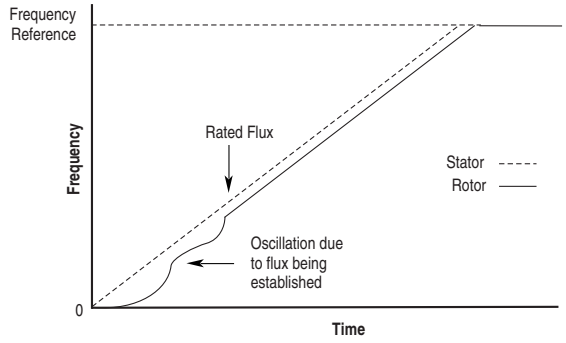
Flux Up

70EC ✓ 700VC ✓

AC induction motors require flux to be established before controlled torque can be developed. To build flux, voltage is applied. There are two methods to flux the motor.

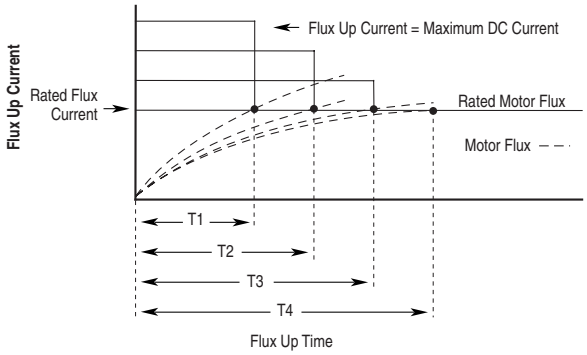
The first method is during a normal start. Flux is established as the output voltage and frequency are applied to the motor. While the flux is being established, the unpredictable nature of the developed torque may cause the rotor to oscillate even though acceleration of the load may occur. In the motor, the acceleration profile may not follow the commanded acceleration profile due to the lack of developed torque.

Figure 5 Accel Profile during Normal Start - No Flux Up



The second method is Flux Up Mode. In this mode, DC current is applied to the motor so that the flux is established before rotation. The flux up time period is based on the level of flux up current and the rotor time constant of the motor. The flux up current is not user adjustable.

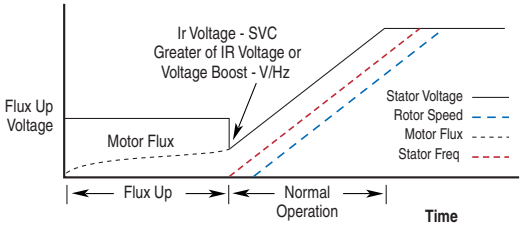
Figure 6 Flux Up Current versus Flux Up Time



[Flux Up Time]

Once rated flux is reached in the motor, normal operation begins and the desired acceleration profile is achieved.

Figure 7 Rated Flux Reached



Flying Start

The Flying Start feature is used to start into a rotating motor, as quick as possible, and resume normal operation with a minimal impact on load or speed.

When a drive is started in its normal mode it initially applies a frequency of 0 Hz and ramps to the desired frequency. If the drive is started in this mode with the motor already spinning, large currents will be generated. An overcurrent trip may result if the current limiter cannot react quickly enough. The likelihood of an overcurrent trip is further increased if there is a residual flux (back emf) on the spinning motor when the drive starts. Even if the current limiter is fast enough to prevent an overcurrent trip, it may take an unacceptable amount of time for synchronization to occur and for the motor to reach its desired frequency. In addition, larger mechanical stress is placed on the application.

In Flying Start mode, the drive's response to a start command is to synchronize with the motors speed (frequency and phase) and voltage. The motor will then accelerate to the desired frequency. This process will prevent an overcurrent trip and significantly reduce the time for the motor to reach its desired frequency. Since the drive synchronizes with the motor at its rotating speed and ramps to the proper speed, little or no mechanical stress is present.

Configuration

Flying Start is activated by setting the [Flying Start En] parameter to "Enable"

The gain can be adjusted to increase responsiveness. Increasing the value in [Flying StartGain] increases the responsiveness of the Flaying Start Feature

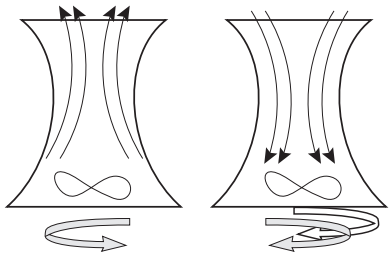
Application Example

In some applications, such as large fans, wind or drafts may rotate the fan in the reverse direction when the drive is stopped. If the drive were started in the normal manner, its output would begin at zero Hz, acting as a brake to bring the reverse rotating fan to a stop and then accelerating it in the correct direction.

This operation can be very hard on the mechanics of the system including fans, belts and other coupling devices.

Cooling Tower Fans

Draft/wind blows idle fans in reverse direction. Restart at zero damages fans, breaks belts. Flying start alleviates the problem



High Resolution Speed Reference

The high resolution speed reference provides a 32 bit (as opposed to a 16 bit) speed reference from a communication network. The high resolution 32 bit reference is scaled so that a value of 2147483647 corresponds to [Maximum Freq], parameter 55 if [DPI Ref Select], parameter 298 = “0, Max Freq,” or 2147483647 corresponds to [Maximum Speed], parameter 82 if [DPI Ref Select] = “1, Max Speed.”

To use the high resolution reference, [Speed Ref A Sel] or [Speed Ref B Sel] is set to “30, HighRes Ref.” Then [HighRes Ref], parameter 308 is used as a reference through datalinks. A pair of datalinks (e.g. A1 and A2 or B1 and B2, etc.) must be set to write to [HighRes Ref].

Example

The following example writes the high resolution reference to a PF70EC on Ethernet from ControlLogix.

Drive Parameter Settings:

- [Speed Ref A Sel], parameter 90 = 30 “HighRes Ref”
- [DPI Ref Select], parameter 298 = 1 “Max Speed”
- [Data In A1], parameter 300 = 308
- [Data In A2], parameter 301 = 308

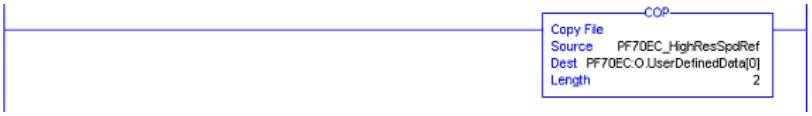
Data In A1 will contain the least significant word (LSW) of the speed reference and Data In A2 will contain the most significant word (MSW) of the speed reference.

ControlLogix Program

A PF70EC is added in I/O Configuration. Then a new tag of type DINT is created for the high resolution speed reference.

Tag Name	Alias For	Type	Style
⊞ PF70EC:I		AB:PowerFlex70_...	
⊞ PF70EC:O		AB:PowerFlex70_...	
⊞ PF70EC_HighResSpdRef		DINT	Decimal

Next, the speed reference is written to the DINT tag “PF70EC_HighResSpdRef.” Using the COP instruction, the DINT tag is copied to 2 UserDefinedData tags. The tag PF70EC:O:UserDefinedData[0] corresponds to Data In A1 in the drive and the tag PF70EC:O:UserDefinedData[1] corresponds to Data In A2.



Setting the tag PF70EC_HighResSpdRef to 2147483647 corresponds to [Max Speed] of the drive.

Important: In 16 bit processors such as the SLC and PLC-5, there are no DINT data types, so the high resolution speed reference remains split as 2 separate 16-bit words.

Input Phase Loss Detection

Occasionally, three-phase power sources can fail on one phase while continuing to deliver power between the remaining 2 phases (single-phase). Operating above 50% output under this single-phase condition can damage the drive. If such a condition is likely, it is recommended that Input Phase Loss Detection be enabled. The drive can be programmed to simply turn on an alarm bit, or also fault the drive. The drive accomplishes this by interpreting voltage ripple on the DC bus.

Configuration

- [Drive Alarm 1], parameter 259, bit 12 - “In Phase Loss” 0 = disabled, 1 = enabled.
- [Fault Config 1], parameter 238, bit 8 - “In Phase Loss” 0 = disabled, 1 = enabled

Language

Seven languages are supported; English, Spanish, German, Italian, French, Portuguese and Dutch. All drive functions and information displayed on an LCD HIM are shown in the selected language. The desired language can be selected by any of the following methods.

- On initial drive power-up, a language choice screen appears.
- The language choice screen can also be recalled at any time to change to a new language. This is accomplished by pressing the “Alt” key followed by the “Lang” key.
- The language can also be changed by selecting the [Language] parameter (201).

Load Loss Detection

The output torque current is monitored by the drive and may be used to indicate a loss of load. This can be used to indicate a mechanical problem with load, or faulty wiring. Both the threshold level and amount of time the condition must be present before action is taken, is adjustable. The drive can be programmed to simply turn on an alarm bit, or also fault the drive.

Configuration

- [Load Loss level], parameter 187, 0-800% of rated motor torque (based on entered nameplate data)
- [Load Loss Time], parameter 188, 0 - 300 seconds
- [Alarm Config 1], parameter 259, bit 13 - “Load Loss” 0 = disabled, 1 = enabled
- [Fault Config 1], parameter 238, bit 9 - “Load Loss” 0 = disabled, 1 = enabled

Masks

A mask is a parameter that contains one bit for each of the possible communication ports. Masking (setting a bit's value to 0) stops the command from reaching the drive logic. Unmasking (setting a bit's value to 1) allows the command to pass through into the drive logic.

Example

A customer's process is normally controlled by a remote PLC, but the drive is mounted on the machine. The customer does not want anyone to reverse the drive by pressing “Reverse” on the locally mounted HIM (DPI port 1), because it would damage the process. To assure that only the PLC (connected to DPI port 5) has direction control, the [Direction Mask] can be set as follows:

Direction Mask

	0	0	1	0	0	0	0	0
Adapter #	X	6	5	4	3	2	1	0

This “masks out” the reverse function from all communication ports except port 5, making the local HIM (port 1) Reverse button inoperable. Also see "Owners" on page 59.

MOP

The Motor Operated Pot (MOP) function uses either digital inputs or network commands to increment or decrement the speed reference at a programmed rate.

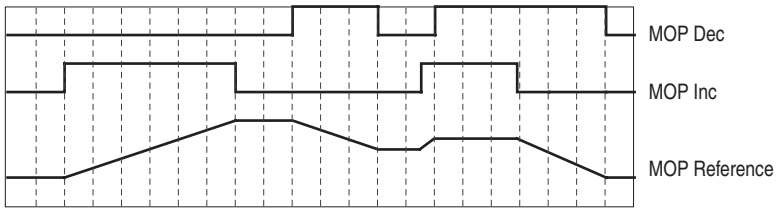
The MOP has three components:

- [MOP Rate] parameter
- [Save MOP Ref] parameter
- [MOP Frequency] parameter

MOP increment input

MOP decrement input

The MOP rate is the rate at which the MOP reference will change when commanded to increment or decrement. This rate is independent of acceleration and deceleration times.



MOP rate is defined in Hz/sec. The MOP reference will increase/decrease linearly at that rate as long as the MOP inc or dec is asserted. Asserting both MOP inc and dec inputs simultaneously will result in no change to the MOP reference.

[Save MOP Ref] is a parameter that provides configurability of the initial MOP reference value after a power down or Stop command.

Bit 0
0 = Don't save MOP reference on power-down (default)
1 = Save MOP reference on power-down

If the value is "SAVE MOP Ref" when the drive power returns, the MOP reference is reloaded with the value from the non-volatile memory. When the bit is set to 0, the MOP reference defaults to zero when power is restored.

Bit 1
0 = Reset MOP reference when STOP is asserted
1 = Don't reset MOP reference when STOP is finished (default)

Important: The MOP reset only occurs when a stop event completes and is not continuously cleared while the drive is stopped. The reset only applies to the stop edge and not when a fault is detected.

Incrementing or decrementing the MOP frequency is independent of whether or not MOP is being used as the speed reference. See "Speed Reference" on page 98 for an explanation of activating a specific speed reference.

The [MOP Frequency] parameter shows the value of the MOP reference.

MOP handling with Direction Mode

If the Direction Mode is configured for "Unipolar," then the MOP decrement will clamp at zero not allowing the user to generate a negative MOP reference that is clamped off by the reference generation. When Direction Mode = "Bipolar" the MOP reference will permit the decrement function to produce negative values. If the drive is configured for Direction Mode = "Bipolar" and then is changed to "Unipolar", the MOP reference will also be clamped at zero if it was less than zero.

Motor Control Modes

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[Motor Cntl Sel] selects the output mode of the drive. The choices are:

- Custom Volts/Hertz
  Used in multi-motor or synchronous motor applications.
- Fan/Pump Volts/Hertz
  Used for centrifugal fan/pump (variable torque) applications to achieve maximum energy savings.
- Sensorless Vector
  Used for most constant torque applications. Provides excellent starting, acceleration and running torque.
- Sensorless Vector w/Economizer
  Used for additional energy savings in constant torque applications that have constant speed reduced load periods.
- Flux Vector
  Used when high performance speed regulation or torque regulation is required.
- Adjustable Voltage ***700VC ONLY***
  Typically used for non-motor applications such as resistive loads, welding equipment and power supplies, but also linear motors.

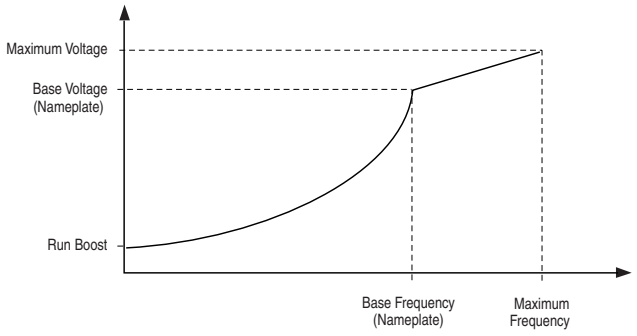
The following table shows the performance differences between V/Hz, Sensorless Vector and Flux Vector.

Torque Mode	Fan/Pump and Custom V/Hz with Slip Comp	SVC with Slip Comp	SVC with Feedback	Flux Vector without Feedback	Flux Vector with Feedback
Speed Regulation (% of base speed)	0.5%	0.5%	0.1%	0.1%	0.001%
Operating Speed Range	40:1	80:1	80:1	120:1	1000:1
Speed Bandwidth	10 rad/sec	20 rad/sec	20 rad/sec	50 rad/sec	≥125 rad/sec
Torque Regulation	N/A	N/A	N/A	≤10%	≤5%

Volts/Hertz

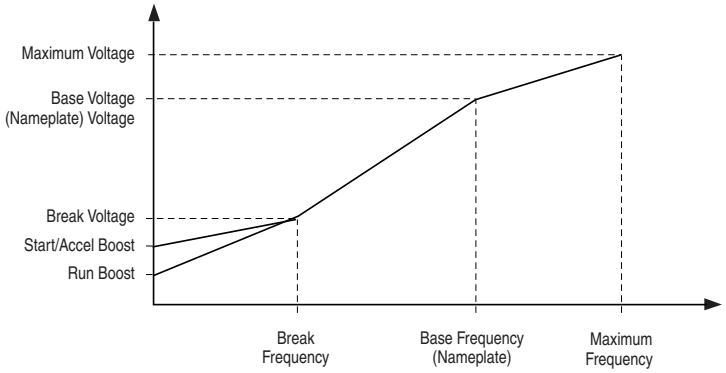
Volts/Hertz operation creates a fixed relationship between output voltage and output frequency. The relationship can be defined in two ways.

1. Fan/Pump
   When this option is chosen, the relationship is $1/x^2$. Therefore; for full frequency, full voltage is supplied and for 1/2 rated frequency, 1/4 voltage is applied, etc. This pattern closely matches the torque requirement of a variable torque load (centrifugal fan or pump – load increases as speed increases) and offers the best energy savings for these applications.



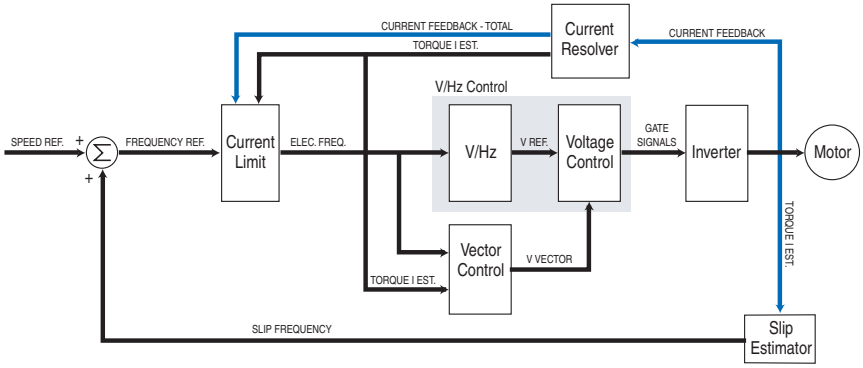
2. Custom
   Custom Volts/Hertz allows a wide variety of patterns. The default configuration is a straight line from zero to rated voltage and frequency. As seen in the diagram below, the volts/hertz ratio can be changed to provide increased torque performance when required by programming 5 distinct points on the curve:

   – **Start Boost** - Used to create additional torque for breakaway from zero speed and acceleration of heavy loads at lower speeds
   – **Run Boost** - Used to create additional running torque at low speeds. The value is typically less than the required acceleration torque. The drive will lower the boost voltage to this level when running at low speeds (not accelerating). This reduces excess motor heating that could be caused if the higher start / accel boost level were used.
   – **Break Voltage/Frequency** - Used to increase the slope of the lower portion of the Volts / hertz curve, providing additional torque.
   – **Motor Nameplate Voltage/Frequency** - sets the upper portion of the curve to match the motor design. Marks the beginning of the constant power region
   – **Maximum Voltage/Frequency** - Slopes the portion of the curve used above base speed.



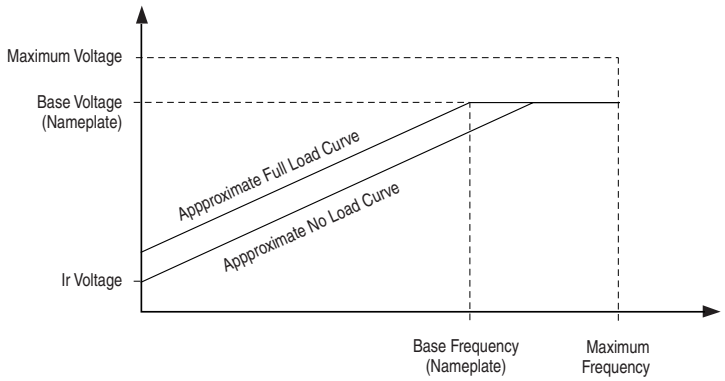
Sensorless Vector

Sensorless Vector mode uses a V/Hz core enhanced by excellent current resolution, a slip estimator, a high performance current limiter and the vector algorithms.



The algorithms operate on the knowledge that motor current is the vector sum of the torque and flux producing components. Values can be entered to identify the motor values or an autotune routine can be run to identify the motor values (see "Autotune" on page 16). Sensorless vector offers better torque production and a wider speed range than V/Hz. However, it may not be appropriate when more than one motor is connected to the same drive.

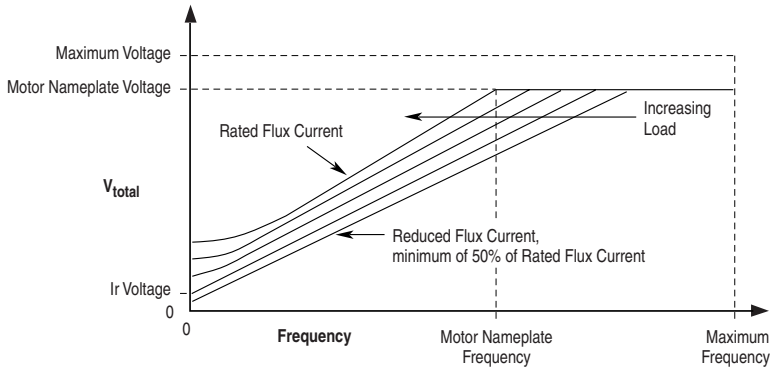
In sensorless vector control, the drive commands a specific amount of voltage to develop flux.



Sensorless Vector w/Economizer

Economizer mode consists of the sensorless vector control with an additional energy savings function.

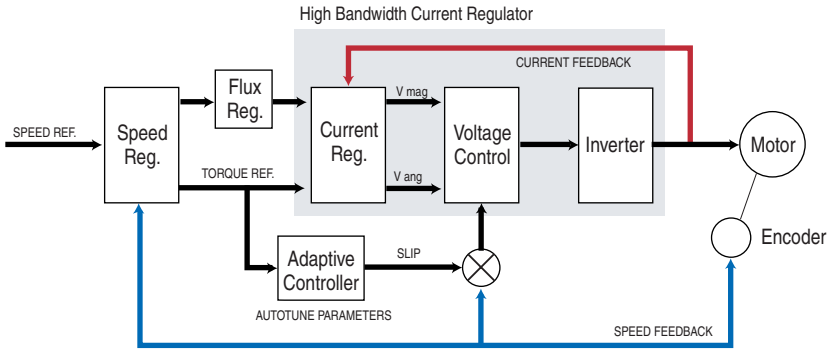
When steady state speed is achieved, the economizer becomes active and automatically adjusts the drive output voltage based on applied load. By matching output voltage to applied load, the motor efficiency is optimized. Reduced load commands a reduction in motor flux current. The flux current is reduced as long as the total drive output current does not exceed 75% of motor rated current as programmed in [Motor NP FLA], parameter 42. The flux current is not allowed to be less than 50% of the motor flux current as programmed in [Flux Current Ref], parameter 63. During acceleration and deceleration, the economizer is inactive and sensorless vector motor control performs normally.



Flux Vector Control

In flux vector mode, the flux and torque producing currents are independently controlled and speed is indirectly controlled by a torque reference. Alternatively, the drive can control torque instead of speed in flux vector mode. In either case, this mode can be operated either with or without feedback and will provide the fastest response to load changes.

Figure 8 Flux Vector



Motor Nameplate Data

70EC ✓ 700VC ✓

These parameters provide motor information to the drive, so the drive can both protect the motor and also make internal adjustments to provide the best performance.

[Motor NP Volts]
The rated voltage as stated on the motor nameplate.

[Motor NP FLA]
The rated full load amps as stated on the motor nameplate.

[Motor NP Hz]
The rated base frequency as stated on the motor nameplate.

[Motor NP RPM]
The rated base speed in RPM as stated on the motor nameplate.

[Motor NP Power]
The rated power as stated on the motor nameplate. This may be entered in horsepower or in kilowatts as selected in [Mtr NP Pwr Units], parameter 46.

[Mtr NP Pwr Units]
Determines the units for [Motor NP Power]. Possible settings are:

- 0 “Horsepower” - units are displayed in HP.
- 1 “kilowatts” - units are displayed in kW.
- 2 “Convert HP” - converts units to HP (from kW) by dividing [Motor NP Power] by 0.746 (PowerFlex 700VC Only).
- 3 “Covert kW” - converts units to kW (from HP) by multiplying [Motor NP Power] by 0.746 (PowerFlex 700VC Only).

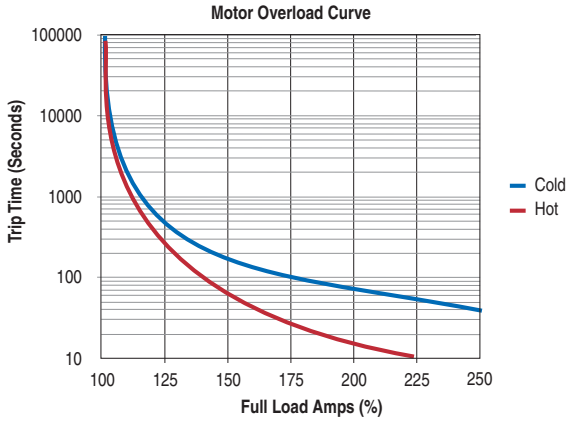
[Motor Poles]
Defines the number of poles in the motor. [Motor Poles] is calculated automatically if the user enters the motor nameplate data through the Assisted Start-up menu of an LCD HIM. The number of motor poles is defined by:

$$P = \frac{120f}{N}$$

where:
P = motor poles
f = base motor frequency (Hz)
N = synchronous RPM at base motor frequency (f)

Motor Overload

The motor overload protection feature uses an IT (inverse time) algorithm to model the temperature of the motor and follows the same curve as a physical class 10 overload device.



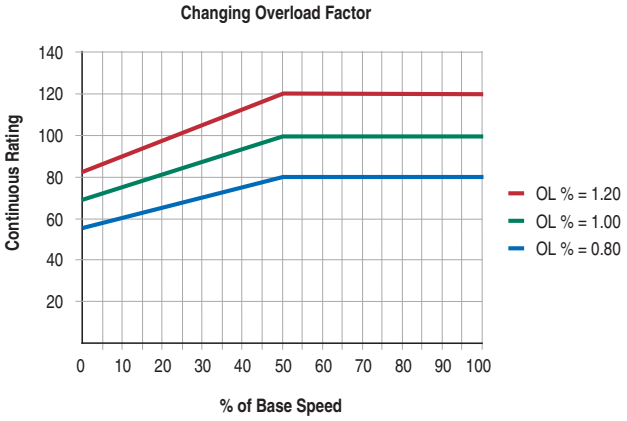
[Motor NP FLA] is used by the overload feature to establish the 100% level (y axis) shown in the graph above.

Setting the correct bit in [Fault Config x] to zero disables the motor thermal overload. For multimotor applications (more than one motor connected to one drive), separate external overloads for each motor are required, and the drive's motor overload can be disabled.

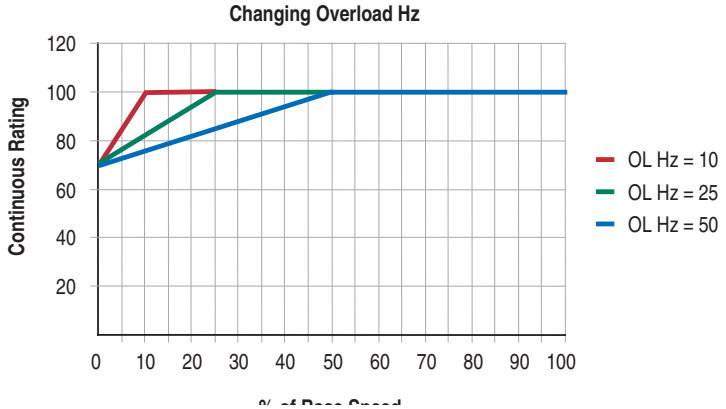
Operation of the overload is based on three parameters; [Motor NP FLA], [Motor OL Factor] and [Motor OL Hertz].

1. [Motor NP FLA] is the base value for motor protection.
2. [Motor OL Factor] is used to adjust for the service factor of the motor. Within the drive, motor nameplate FLA is multiplied by motor overload factor to select the rated current for the motor thermal overload. This can be used to raise or lower the level of current that will cause the motor thermal overload to trip without the need to adjust the motor FLA. For example, if motor nameplate FLA is 10 Amps and motor overload factor is 1.2, then motor thermal overload will use 12 Amps as 100%.

   Important: Some motors have a service factor that is only for use with sine wave (non-drive) power. Check with the motor manufacturer to see if the nameplate service factor is valid or must be reduced when operated by a drive.

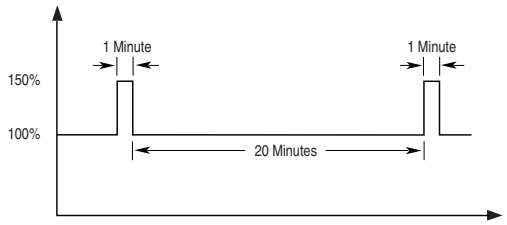


3. [Motor OL Hertz] is used to further protect motors with limited speed ranges. Since many motors do not have sufficient cooling ability at lower speeds, the overload feature can be programmed to increase protection in the lower speed areas. This parameter defines the frequency where derating the motor overload capacity should begin. For all settings of overload Hz other than zero, the overload capacity is reduced to 70% when output frequency is zero. During DC injection braking, the motor current may exceed 70% of FLA, but this will cause the motor overload to trip sooner than when operating at base speed. At low frequencies, the limiting factor may be the drive overload rather than the motor overload.



Duty Cycle for the Motor Overload

When the motor is cold, this function will allow 3 minutes at 150%. When the motor is hot, it will allow 1 minute at 150%. A continuous load of 102% is allowed to avoid nuisance faults. The duty cycle of the motor overload is defined as follows. If operating continuous at 100% FLA, and the load increases to 150% FLA for 59 seconds and then returns to 100%FLA, the load must remain at 100% FLA for 20 minutes to reach steady state.



The ratio of 1:20 is the same for all durations of 150%. When operating continuous at 100%, if the load increases to 150% for 1 second the load must then return to 100% for 20 seconds before another step to 150%.

FLA%	Cold Trip Time	Hot Trip Time
105	6320	5995
110	1794	1500
115	934	667
120	619	375
125	456	240
130	357	167
135	291	122
140	244	94
145	209	74
150	180	60

FLA%	Cold Trip Time	Hot Trip Time
155	160	50
160	142	42
165	128	36
170	115	31
175	105	27
180	96	23
185	88	21
190	82	19
195	76	17
200	70	15

FLA%	Cold Trip Time	Hot Trip Time
205	66	14
210	62	12
215	58	11
220	54	10
225	51	10
230	48	9
235	46	8
240	44	8
245	41	7
250	39	7

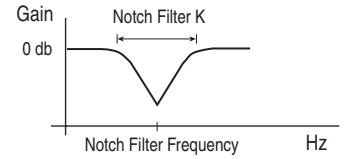
Important: If the application requires high overload current for long durations (e.g. 150% for 60 seconds), heavy duty sizing (between drive and motor) will be required. See "Normal Duty and Heavy Duty Operation" on page 39.

Notch Filter

70EC 700VC

A notch filter exists in the torque reference loop to reduce mechanical resonance created by a gear train. [Notch Filter Freq] sets the center frequency for the 2 pole notch filter, and [Notch Filter K] sets the gain.

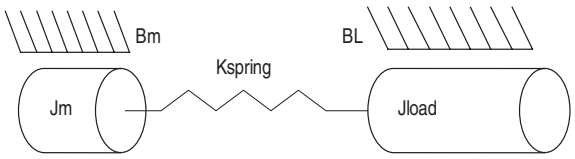
Figure 9 Notch Filter Frequency



Example

A mechanical gear train consists of two masses (the motor and the load) and spring (mechanical coupling between the two loads). See Figure 10.

Figure 10 Mechanical Gear Train



The resonant frequency is defined by the following equation:

$$\text{resonance} = \sqrt{\text{Kspring}\frac{(\text{Jm} + \text{Jload})}{\text{Jm} \times \text{Jload}}}$$

Jm is the motor inertia (seconds)
Jload is the load inertia (seconds)
Kspring is the coupling spring constant (rad^2/sec)

Figure 11 shows a two mass system with a resonant frequency of 62 radians/second (9.87 Hz). One Hertz is equal to 2π radians/second.

Figure 11 Resonance

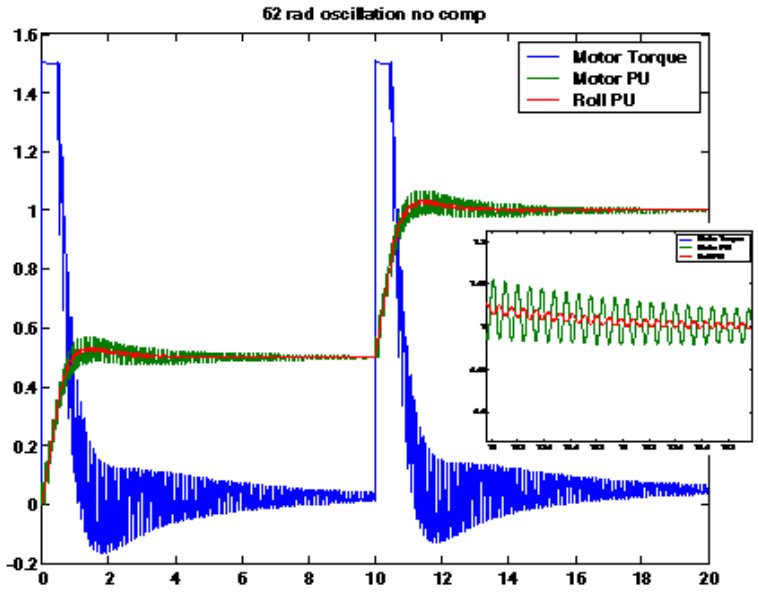
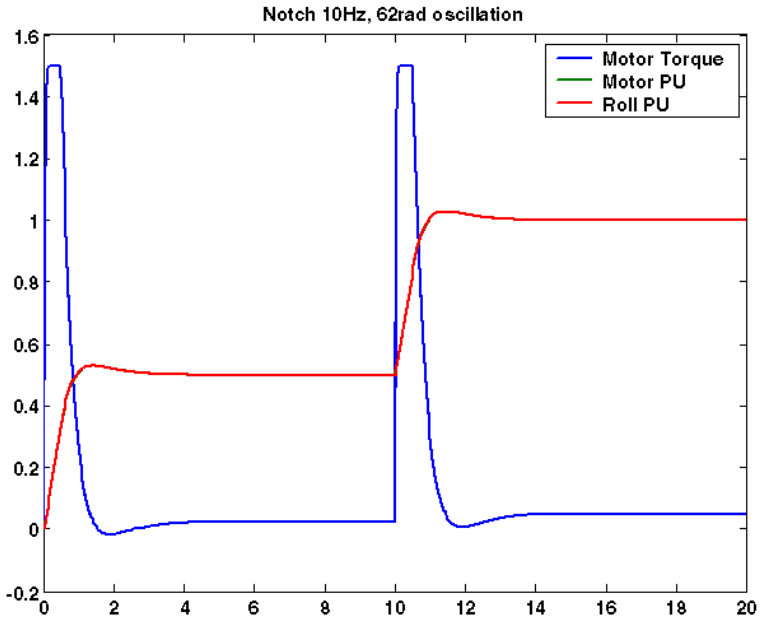


Figure 12 represents the same mechanical gear train but with [Notch Filter Freq] set to 10.

Figure 12 10 Hz Notch



Owners

Owners are status parameters that show which peripheral devices (HIMs, comm ports, etc.) are commanding or have exclusive control of specific control functions. The list of devices also includes the drive's control terminal block.

Exclusive

Only one device at a time can control the drive and only one owner bit will be high. The following owners are Exclusive:

- [Direction Owner]
- [Reference Owner]
- [Accel Owner]
- [Decel Owner]
- [Local Owner]

Non Exclusive

Multiple devices can simultaneously issue the same command and multiple owner bits may be high. The following owners are Not Exclusive:

- [Stop]
- [Start Owner]
- [Jog Owner]
- [Fault Clr Owner]
- [MOP Owner]

Example

The operator presses the Stop button on the Local HIM to stop the drive. When the operator attempts to restart the drive by pressing the HIM Start button, the drive does not restart. The operator needs to determine why the drive will not restart.

Start Owner

	0	0	0	0	0	0	1	0
Adapter #	X	6	5	4	3	2	1	0

When the local Start button is pressed, the display indicates that the command is coming from the HIM.

Stop Owner

	0	0	0	0	0	0	0	1
Adapter #	X	6	5	4	3	2	1	0

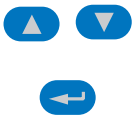
The operator then checks the Stop Owner. Notice that bit 0 is a value of "1," indicating that the Stop device wired to the digital input terminal block is open, issuing a Stop command to the drive.Until this device is reclosed, a permanent Start Inhibit condition exists and the drive will not restart.

Password

70EC ✓ 700VC ✓

By default the password is set to 00000 (password protection disabled).

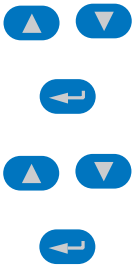
Logging in to the Drive

Step	Key(s)	Example Displays
1. Press the Up or Down Arrow to enter your password. Press Sel to move from digit to digit. 2. Press Enter to log in.		Login: Enter Password 9999

Logging Out

Step	Key(s)	Example Displays
You are automatically logged out when the User Display appears. If you want to log out before that, select “log out” from the Main Menu.		

To change a password

Step	Key(s)	Example Displays
1. Use the Up Arrow or Down Arrow to scroll to Operator Intrfc. Press Enter. 2. Select “Change Password” and press Enter. 3. Enter the old password. If a password has not been set, type “0.” Press Enter. 4. Enter a new password (1- 65535). Press Enter and verify the new password. Press Enter to save the new password.		Operator Intrfc: Change Password User Display Parameters Password: Old Code: 0 New Code: 9999

Position Indexer/ Speed Profiler

Overview

The profile/indexer may be configured as a velocity regulator or a position regulator. If position control is desired, encoder feedback is required. Parameter 088, [Speed/Torque Mod] is used to select the “Pos/Spd Prof” mode. Sixteen steps are available with this feature.

Common Guidelines for all step types

Direction Control - The drive must be configured to allow the profile to control the direction. This is accomplished by setting [Direction Mode], parameter 190 to “Bipolar.”

Limits - Many threshold values can affect the performance of the profile/indexer. To help minimize the possibility of overshooting a position, ensure that the following parameters are set for the best performance.

[Regen Power Limit] - default is –50% and will likely require a greater negative value. A brake or other means of dissipating regenerative energy is recommended.

[Current Lmt Sel] & [Current Lmt Value] - By default these parameters are set to provide 150% of drive rating. If lowered, the performance may be degraded.

[Bus Reg Mode A] - The default setting will adjust frequency to regulate the DC bus voltage under regenerative conditions. This will most likely cause a position overshoot. To resolve this, select “Dynamic Brak” and size the load resistor for the application.

[Bus Reg Mode B] - The default setting will adjust frequency to regulate the DC bus voltage under regenerative conditions. This will most likely cause a position overshoot. To resolve this, select “Dynamic Brak” and size the load resistor for the application.

Speed Regulator - The bandwidth of the speed regulator will affect the performance. If the connected inertia is relatively high, the bandwidth will be low and therefore a bit sluggish. When programming the acceleration and deceleration rates for each step, do not make them too aggressive or the regulator will be limited and therefore overshoot the desired position.

Position Loop Tuning

Two parameters are available for tuning the position loop. [Pos Reg Filter], parameter 718 is a low pass filter at the input of the position regulator. [Pos Reg Gain], parameter 719 is a single adjustment for increasing or decreasing the responsiveness of the regulator. By default these parameters are set at roughly a 6:1 ratio (filter = 25, gain = 4). It is recommended that a minimum ratio of 4:1 be maintained.

Jogging

A jog function is compatible with profiling but the drive must be in a stopped condition. If the drive is presently running a profile, the jog will be ignored. The direction of the jog is controlled by the sign of the jog speed. This can be manipulated via analog input scaling, from a network communication device or with the HIM module.

Profile Command Control Word

The profile/indexer is controlled with [Profile Command], parameter 705. The bit definitions are as follows:

Bit	Name	Description
0	Start Step 0	The binary value of these bits determines which step will be the starting step for the profile when a start command is issued. If the value of these bits are not 1-16 the drive will not run since it does not have a valid step to start from. Valid Examples: 00011 = step 3, 01100 = step 12
1	Start Step 1	
2	Start Step 2	
3	Start Step 3	
4	Start Step 4	
5-7	Reserved	Not used
8	Hold Step	When set, this command will inhibit the profile from transitioning to the next step when the condition(s) required are satisfied. When the Hold command is released, the profile will transition to the next step.
9	Pos Redefine	This bit is used to set the present position as Home. When this bit is set, [Profile Status] bit "At Home" will be set and the [Units Traveled] will be set to zero.
10	Find Home	This bit is used to command the Find Home routine.
11	Vel Override	When this bit is set the velocity of the present step will be multiplied by the value in [Vel Override].
12-31	Reserved	Not used.

The bits in [Profile Command] can be set via DPI interface (HIM or Comm) or digital inputs. When digital input(s) are programmed for "Pos Sel 1-5," the starting step of the profile is exclusively controlled by the digital inputs. The DPI interface value for bits 0-4 will be ignored.

If a digital input is configured for bit 8-11 functions of the [Profile Command], the DPI interface or the digital input can activate the command.

Velocity Regulated Step Parameters

Each of the Velocity Regulated steps has the following associated parameters or functions:

	Step Type					
	Time	**Time Blend**	**Digital Input**	**Encoder Incremental Blend**	**Parameter Level**	**End**
Value	Total Move Time	Total Time	Digital Input Number	Position & Direction	Parameter Number ±	X
Velocity	Speed & Direction	Speed & Direction	Speed & Direction	Speed	Speed & Direction	X
Accel Time	Accel Rate	Accel Rate	Accel Rate	Accel Rate	Accel Rate	X
Decel Time	Decel Rate	Decel Rate	Decel Rate	Decel Rate	Decel Rate	Decel Rate
Next Step Condition	Time greater than [Step Value]	Time greater than [Step Value]	Digital Input logic	At Position [Step Value]	[Step Value] > or < [Step Dwell]	At Zero transition
Dwell	Dwell Time	X	Dwell Time	X	Compare Value	Dwell Time
Batch	Batch Number	X	Batch Number	X	X	X
Next	Next Step	Next Step	Next Step	Next Step	Next Step	X (Stop)

X = Function not applicable to this step type

Position Regulated Step Parameters

Each of the Position Regulated steps has the following associated parameters or functions:

	Step Type		
	Encoder Absolute	**Encoder Incremental**	**End Hold Position**
Value	Position & Direction	Position & Direction	X
Velocity	Speed	Speed	X
Accel Time	Accel Rate	Accel Rate	X
Decel Time	Decel Rate	Decel Rate	X
Next Step Condition	At Position = 1	At Position =1	At Position =1
Dwell	Dwell Time	Dwell Time	Dwell Time
Batch	X	Batch Number	X
Next	Next Step	Next Step	X (Stop)

X = Function not applicable to this step type

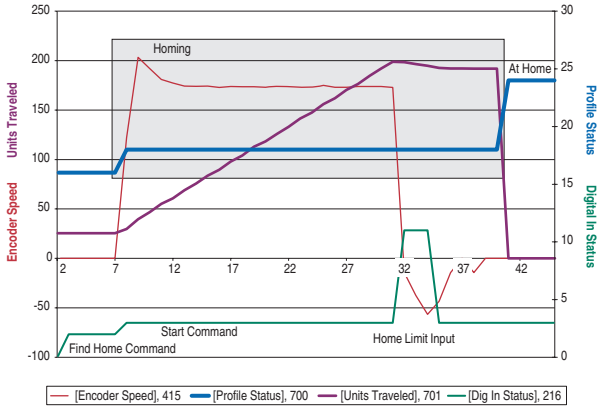
Homing Routine

Each time the profile/indexer is enabled, the drive requires a home position to be detected. The following options are available:

Homing to Marker Pulse with Encoder Feedback - When “Find Home” is commanded, the homing routine is run when a start command is issued. The Homing bit (11) in [Profile Status], parameter 700 will be set while the homing routine is running. The drive will ramp to the speed and direction set in [Find Home Speed], parameter 713 at the rate set in [Find Home Ramp], parameter 714 until the digital input defined as Home Limit is activated. The drive will then ramp to zero and then back up to first marker pulse prior to the Home Limit switch at 1/10th the [Find Home Speed]. When on the marker pulse, the At Home bit (13) is set in the [Profile Status] and the drive is stopped.

The diagram below shows the sequence of operation for homing to a marker pulse. [Encoder Z Chan], parameter 423 must be set to “Marker Input” or “Marker Check” for this type of homing.

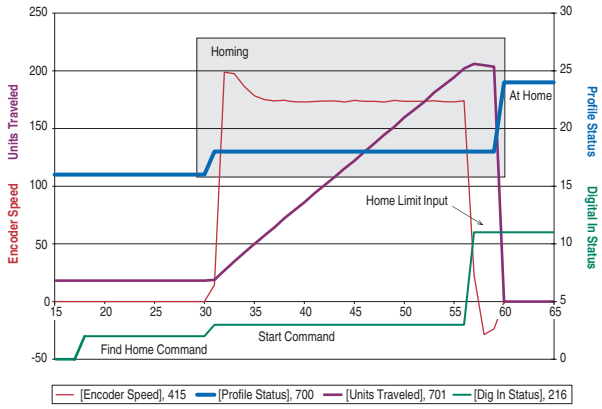
Homing to Marker



Homing to Limit Switch with Encoder Feedback - When “Find Home” is commanded, the homing routine is run when a start command is issued. The Homing bit (11) in [Profile Status], parameter 700 will be set while the homing routine is running. The drive will ramp to the speed and direction set in [Find Home Speed], parameter 713 at the rate set in [Find Home Ramp], parameter 714 until the digital input defined as Home Limit is activated. The drive will then reverse direction at 1/10th the [Find Home Speed] to the point where the Home Limit switch activated and stop.

The diagram below shows the sequence of operation for homing to a limit switch with encoder feedback (without a marker pulse). [Encoder Z Chan], parameter 423 must be set to “Pulse Input” or “Pulse Check.”

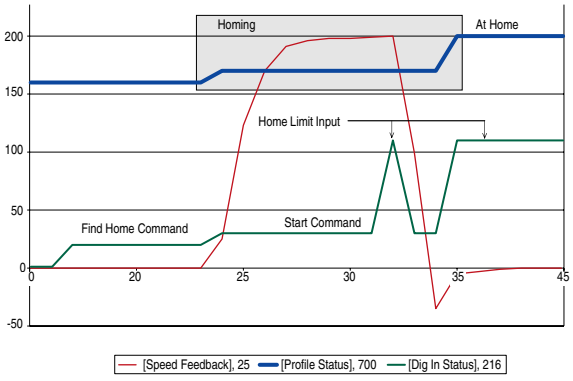
Homing to Limit Switch



Homing to Limit Switch w/o Encoder Feedback - When “Find Home” is commanded, the homing routine is run when a start command is issued. The Homing bit (11) in [Profile Status], parameter 700 will be set while the homing routine is running. The drive will ramp to the speed and direction set in [Find Home Speed], parameter 713 at the rate set in [Find Home Ramp], parameter 714 until the digital input defined as Home Limit is activated. The drive will then decelerate to zero. If the switch is no longer activated, the drive will reverse direction at 1/10th the [Find Home Speed] to the switch position and then stop. The Home Limit switch will be active when stopped.

The diagram below shows the sequence of operation for homing to a limit switch without encoder feedback.

Homing to Limit Switch (No Feedback)



Position Redefine – When “Pos Redefine” is set, the present position is established as home and [Units Traveled] is set to zero.

Disable Homing Requirement – If a home position is not required, the routine can be disabled by clearing [Alarm Config 1] bit 17 “Prof SetHome” to “0.” This will disable the alarm from being set when “Pos/Spd Prof” mode is configured in [Speed/Torque Mod] and will set the present position as home.

Once Homing is complete the “Find Home” command must be removed to allow the profile to be run. If the “Find Home” command is not removed, when the drive is started, the routine will see that it is At Home and the drive will stop.

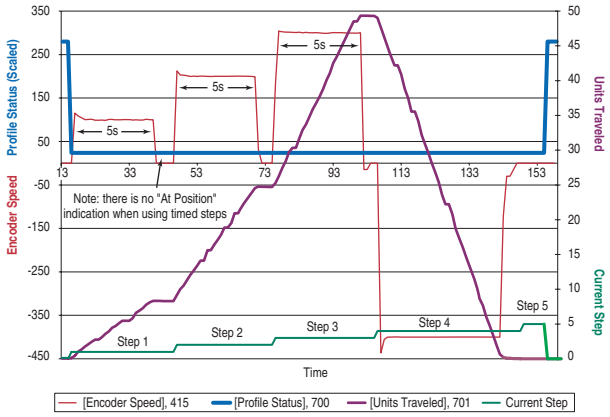
Velocity Regulator Step Types

End – The drive ramps to zero speed and stops the profile. It clears the current step bits and sets the Complete bit (14) in [Profile Status], parameter 700 word.

Time – When started, the drive will ramp to the desired velocity, hold the speed, and then ramp to zero in the programmed time for the given step.

The example below shows a five step profile. The first 3 are Time steps followed an Encoder Abs step to zero then an End step. For each Time step the drive ramps at [Step X AccelTime] to [Step X Velocity] in the direction of the sign of [Step X Velocity]. The drive then decelerates at [Step X DecelTime] to zero. The [Step X Value] is programmed to the desired time for the total time of the accel, run and decel of the step. Each step has a 1 second time programmed in [Step X Dwell] which is applied to the end of each step. After the dwell time expires, the profile transitions to the next step. The absolute step is used to send the profile back to the home position. This is done by programming [Step 4 Value] to zero.

Timed Steps

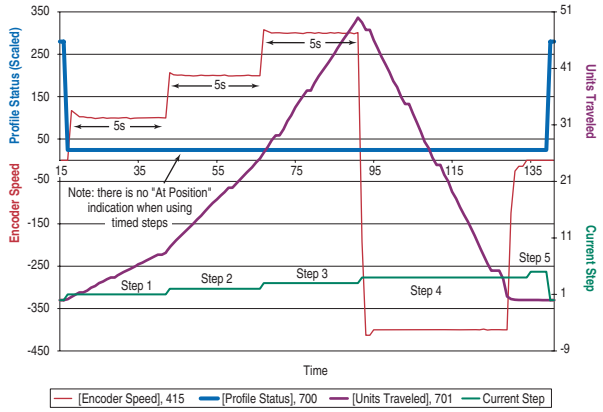


Step #	Step X Type	Step X Velocity	Step X AccelTime	Step X DecelTime	Step X Value	Step X Dwell	Step X Batch	Step X Next
1	Time	100	0.5	0.5	5.00	1.00	1	2
2	Time	200	0.5	0.5	5.00	1.00	1	3
3	Time	300	0.5	0.5	5.00	1.00	1	4
4	Encoder Abs	400	0.5	0.5	0.00	1.00	1	5
5	End	N/A	N/A	0.5	N/A	0.00	N/A	N/A

Time Blend - When started the drive will ramp to the desired velocity and hold speed for the programmed time at which point it will transition to the next step and ramp to the programmed velocity without going to zero speed.

The example below shows a five step profile. The first three are Time Blend steps followed by an Encoder Abs step to zero then an End step. For each Time Blend step the drive ramps at [Step X AccelTime] to [Step X Velocity] in the direction of the sign of [Step X Velocity]. The [Step X Value] is programmed to the desired time for the total time of the accel and run of the step. When the value programmed in [Step X Value] is reached, the profile transitions to the next step. The absolute step is used to send the profile back to the home position. This is done by programming [Step 4 Value] to zero.

Timed Steps Blended

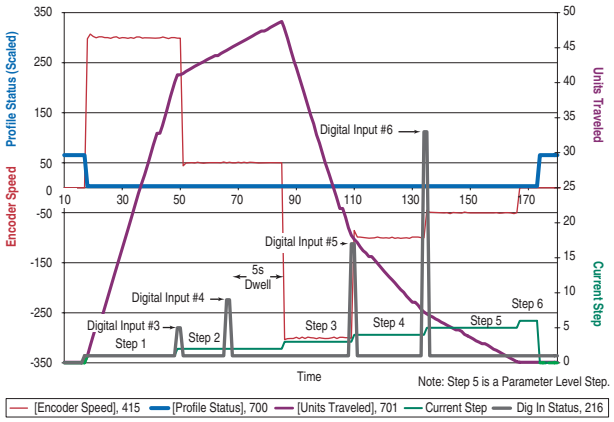


Step #	Step X Type	Step X Velocity	Step X AccelTime	Step X DecelTime	Step X Value	Step X Dwell	Step X Batch	Step X Next
1	Time Blend	100	0.5	0.5	5.00	0.00	1	2
2	Time Blend	200	0.5	0.5	5.00	0.00	1	3
3	Time Blend	300	0.5	0.5	5.00	0.00	1	4
4	Encoder Abs	400	0.5	0.5	0.00	1.00	1	5
5	End	N/A	N/A	0.5	N/A	0.00	N/A	N/A

Digital Input - When started, the drive will ramp to the desired velocity and hold speed until the digital input programmed in the value transitions in the direction defined. When this occurs, the profile will transition to the next step and ramp to the programmed velocity without going to zero speed.

The example below shows a six step profile. In each step, the drive ramps at [Step X AccelTime] to [Step X Velocity] in the direction of the sign of [Step X Velocity] until a digital input is detected. When the input is detected it transitions to the next step in the profile. This continues through DigIn6 activating step 5. Step 5 is defined as a Parameter Level step. Digital Inputs used in the profile must be defined as “Prof Input.”

Digital Inputs

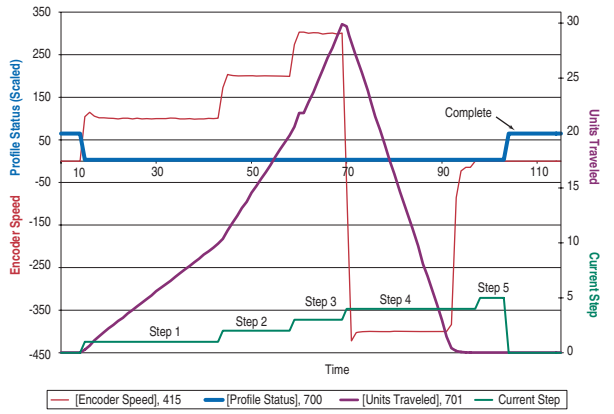


Step #	Step X Type	Step X Velocity	Step X AccelTime	Step X DecelTime	Step X Value	Step X Dwell	Step X Batch	Step X Next
1	Digital Input	300	0.5	0.5	3.00	0.00	1	2
2	Digital Input	50	0.5	0.5	4.00	5.00	1	3
3	Digital Input	-300	0.5	0.5	5.00	0.00	1	4
4	Digital Input	-100	0.5	0.5	6.00	1.00	1	5
5	Param Level	-50	0.5	0.5	701	0.00	1	6
6	End	N/A	N/A	0.5	N/A	0.00	N/A	N/A

Encoder Incremental Blend (EncIncrBlend) - When started, the drive will ramp to the desired velocity and hold speed until the units of travel programmed is reached (within tolerance window). The profile will then transition to the next step and the drive will ramp to the speed of the new step without first going to zero speed.

The example below shows a five step profile. The first three are “EncIncrBlend” steps followed an “Encoder Abs” step to zero then an “End” step. For each “EncIncrBlend” step the drive ramps at [Step X AccelTime] to [Step X Velocity] in the direction of the sign of [Step X Value]. The [Step X Value] is programmed to the desired units of travel for the step. When the value programmed in [Step X Value] is reached, the profile transitions to the next step. The absolute step is used to send the profile back to the home position. This is done by programming [Step 4 Value] to zero.

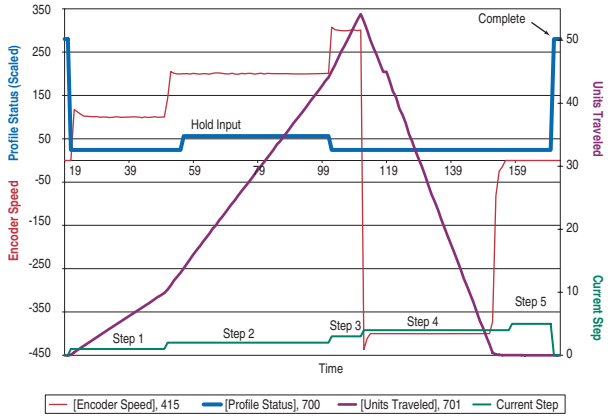
Encoder Incremental Blend



Step #	Step X Type	Step X Velocity	Step X AccelTime	Step X DecelTime	Step X Value	Step X Dwell	Step X Batch	Step X Next
1	EncInc Blend	100	0.5	0.5	10.00	0.00	1	2
2	EncInc Blend	200	0.5	0.5	10.00	0.00	1	3
3	EncInc Blend	300	0.5	0.5	10.00	0.00	1	4
4	Encoder Abs	400	0.5	0.5	0.00	1.00	1	5
5	End	N/A	N/A	0.5	N/A	0.00	N/A	N/A

Encoder Incremental Blend with Hold - This profile is the same as the previous, but contains the Hold function. While the Hold is applied, the step transition is inhibited. When the Hold is released the step can then transition if the conditions to transition are satisfied.

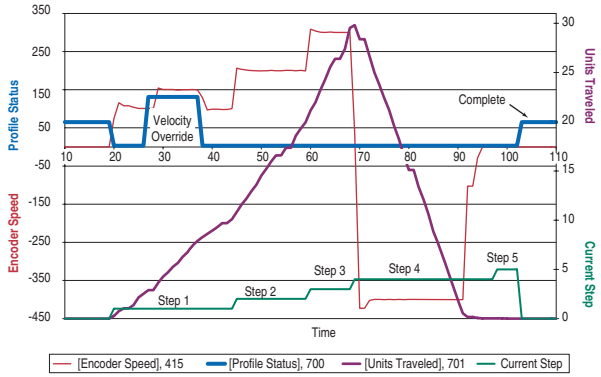
Encoder Incremental Blend w/Hold



Step #	Step X Type	Step X Velocity	Step X AccelTime	Step X DecelTime	Step X Value	Step X Dwell	Step X Batch	Step X Next
1	EncInc Blend	100	0.5	0.5	10.00	0.00	1	2
2	EncInc Blend	200	0.5	0.5	10.00	0.00	1	3
3	EncInc Blend	300	0.5	0.5	10.00	0.00	1	4
4	Encoder Abs	400	0.5	0.5	0.00	1.00	1	5
5	End	N/A	N/A	0.5	N/A	0.00	N/A	N/A

Encoder Incremental Blend with Velocity Override - This profile is the same as the "EncIncrBlend," but contains the Velocity Override function. While the "Vel Override" is applied, the velocity of the step will be multiplied by [Vel Override], parameter 711. In the example below during step 1 the Vel Override was toggled. The speed was multiplied by 150% causing the speed to be 150 RPM rather than 100. When released the speed resumed to the programmed [Step 1 Velocity] of 100rpm.

Encoder Incremental Blend w/Velocity Override



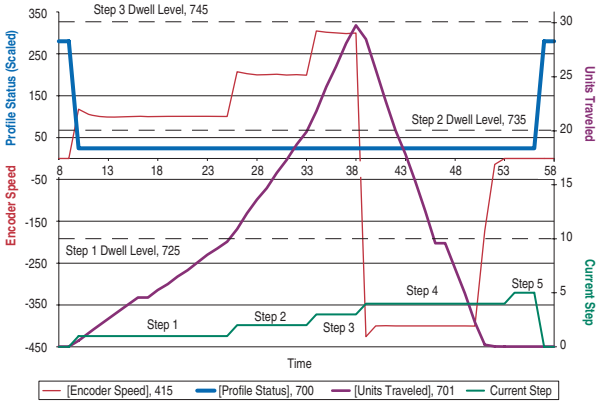
Step #	Step X Type	Step X Velocity	Step X AccelTime	Step X DecelTime	Step X Value	Step X Dwell	Step X Batch	Step X Next
1	EncInc Blend	100	0.5	0.5	10.00	0.00	1	2
2	EncInc Blend	200	0.5	0.5	10.00	0.00	1	3
3	EncInc Blend	300	0.5	0.5	10.00	0.00	1	4
4	Encoder Abs	400	0.5	0.5	0.00	1.00	1	5
5	End	N/A	N/A	0.5	N/A	0.00	N/A	N/A

Parameter Level (Param Level) - When started the drive will ramp to the desired velocity, hold speed and compare the programmed step value to the step dwell level. The sign of the step value defines “less than or greater than” step dwell. When true, the profile will transition to the next step.

The example below shows a five step profile using “Param Level” steps followed by an “Encoder Abs” then an “End” step. For each “Param Level” step the drive ramps at [Step X AccelTime] to [Step X Velocity] in the direction of the sign of [Step X Velocity]. The [Step X Value] is programmed to the parameter number to monitor. The [Step X Dwell] is the value used to compare against the [Step X Value]. The sign of [Step X Value] sets a less than or greater than comparison (– equals < and + equals >). When the comparison of [Step X Value] and [Step X Dwell] is satisfied the profile transitions to the next step. The “Encoder Abs” step is used to send the profile back to the home position. This is done by programming [Step 4 Value] to zero.

In the example [Step 1,2,3 Value] is set to “701.” The value of [Units Traveled], parameter 701 is now a greater than comparison with the step dwell parameters. [Step 1 Dwell] = 10, [Step 2 Dwell] = 20, and [Step 3 Dwell] = 30. When step 1 is beyond 10 Units Traveled, the profile transitions to step 2. When step 2 is greater than 20 Units Traveled the profile transitions to step 3. The transition from step 3 to step 4 happens when Units Traveled is above 30.

Parameter Level



Step #	Step X Type	Step X Velocity	Step X AccelTime	Step X DecelTime	Step X Value	Step X Dwell	Step X Batch	Step X Next
1	Param Level	100	0.5	0.5	701	10.00	1	2
2	Param Level	200	0.5	0.5	701	20.00	1	3
3	Param Level	300	0.5	0.5	701	30.00	1	4
4	Encoder Abs	400	0.5	0.5	0.00	1.00	1	5
5	End	N/A	N/A	0.5	N/A	0.00	N/A	N/A

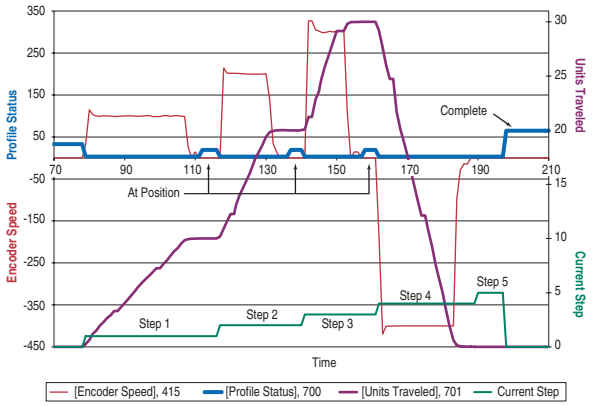
Note: A negative number in the [Step X Value] will transition when the comparison is less than the [Step X Dwell].

Position Regulator Step Types

Encoder Incremental (Encoder Incr) - This is a move increment from the current position in the direction, distance and speed programmed. When started the drive ramps to the desired velocity, holds the speed, then ramps to zero speed at the position desired within the tolerance window.

The example below shows a five step profile. The first three are “Encoder Incr steps” followed by an “Encoder Abs” step to zero then an “End” step. For each “Encoder Incr” step the drive ramps at [Step X AccelTime] to [Step X Velocity] in the direction of the sign of [Step X Value] then decelerates at the rate of [Step X DecelTime] to the position programmed in [Step X Value] which sets the desired units of travel for the step. When the value programmed in [Step X Value] is reached within the tolerance window programmed in [Encoder Pos Tol], the “At Position” bit is set in [Profile Status]. In this example a dwell value held each of the first three steps “At Position” for 1 second. After the [Step X Dwell] time expires the profile transitions to the next step. The absolute step is used to send the profile back to the home position. This is done by programming [Step 4 Value] to zero.

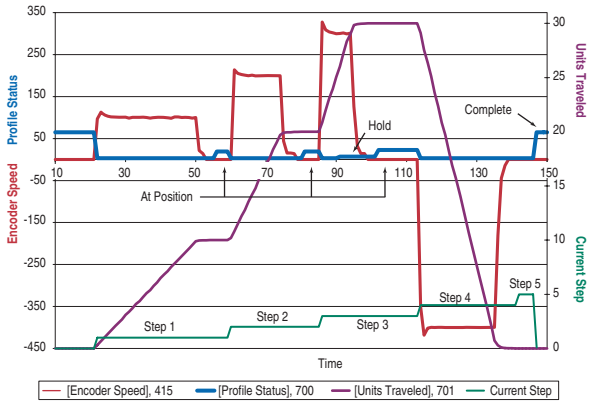
Encoder Incremental w/Dwell



Step #	Step X Type	Step X Velocity	Step X AccelTime	Step X DecelTime	Step X Value	Step X Dwell	Step X Batch	Step X Next
1	Encoder Incr	100	0.5	0.5	10.00	1.00	1	2
2	Encoder Incr	200	0.5	0.5	10.00	1.00	1	3
3	Encoder Incr	300	0.5	0.5	10.00	1.00	1	4
4	Encoder Abs	400	0.5	0.5	0.00	1.00	1	5
5	End	N/A	N/A	0.5	N/A	0.00	N/A	N/A

Encoder Incremental with Hold - This profile is the same as Encoder Incr, but contains the “Hold” function. During step 3 the “Hold” bit was set. After some time “At Position” the “Hold” was removed which allowed the profile to transition to the next step.

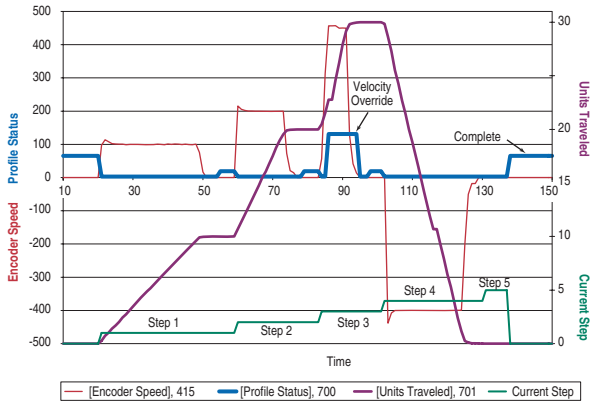
Encoder Incremental w/Dwell and Hold



Step #	Step X Type	Step X Velocity	Step X AccelTime	Step X DecelTime	Step X Value	Step X Dwell	Step X Batch	Step X Next
1	Encoder Incr	100	0.5	0.5	10.00	1.00	1	2
2	Encoder Incr	200	0.5	0.5	10.00	1.00	1	3
3	Encoder Incr	300	0.5	0.5	10.00	1.00	1	4
4	Encoder Abs	400	0.5	0.5	0.00	1.00	1	5
5	End	N/A	N/A	0.5	N/A	0.00	N/A	N/A

Encoder Incremental with Velocity Override - This profile is the same as Encoder Incr, but contains the “Velocity Override” function. During step 3 the “Vel Override” bit was set. While active the [Step 3 Velocity] is multiplied by [Vel Override]. In this example [Vel Override] is 150% causing the speed to be 450rpm rather than 300.

Encoder Incremental w/Dwell and Velocity Override



Step #	Step X Type	Step X Velocity	Step X AccelTime	Step X DecelTime	Step X Value	Step X Dwell	Step X Batch	Step X Next
1	Encoder Incr	100	0.5	0.5	10.00	1.00	1	2
2	Encoder Incr	200	0.5	0.5	10.00	1.00	1	3
3	Encoder Incr	300	0.5	0.5	10.00	1.00	1	4
4	Encoder Abs	400	0.5	0.5	0.00	1.00	1	5
5	End	N/A	N/A	0.5	N/A	0.00	N/A	N/A

End Hold Position – The drive holds the last position and stops the profile after dwell time expires.

Encoder Absolute – This is a move to an absolute position, which is referenced from the home position. When started the drive ramps to the desired velocity in the direction required, holds the speed, then ramps to zero speed at the position desired within the tolerance window.

Power Loss

The drive contains a sophisticated algorithm to manage initial application of power as well as recovery from a partial power loss event. The drive also has programmable features that can minimize the problems associated with a loss of power in certain applications.

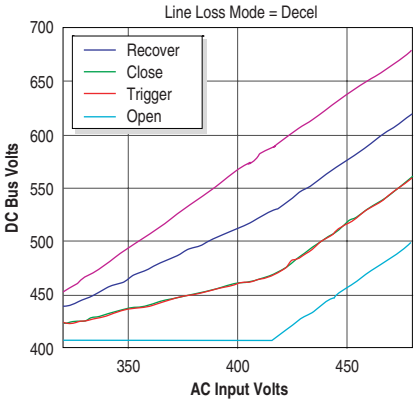
Terms

The following terms are used internally by the drive and are defined below for a complete understanding of power loss functionality.

Term	Definition
Vbus	The instantaneous DC bus voltage.
Vmem	The average DC bus voltage. A measure of the "average" bus voltage determined by heavily filtering bus voltage. Just after the pre-charge relay is closed during the initial power-up bus pre-charge, bus memory is set equal to bus voltage. Thereafter it is updated by ramping at a very slow rate toward V_{bus}. The filtered value ramps at 2.4V DC per minute (for a 480VAC drive). An increase in V_{mem} is blocked during deceleration to prevent a false high value due to the bus being pumped up by regeneration. Any change to V_{mem} is blocked during inertia ride through.
Vslew	The rate of change of V_{mem} in volts per minute.
Vrecover	The threshold for recovery from power loss.
Vtrigger	The threshold to detect power loss. PowerFlex 700VC The level is adjustable. The default is the value in the PF700 Bus Level table. If "Pwr Loss Lvl" is selected as an input function AND energized, $V_{trigger}$ is set to Vmem minus [Power Loss Level]. Vopen is normally 60V DC below $V_{trigger}$ (in a 480VAC drive). Both V_{open} and $V_{trigger}$ are limited to a minimum of V_{min}. This is only a factor if [Power Loss Level] is set to a large value. PowerFlex 70EC This is a fixed value. **WARNING:** When using a value of Parameter #186 [Power Loss Level] larger than default, the customer must provide a minimum line impedance to limit inrush current when the power line recovers. The input impedance should be equal or greater than the equivalent of a 5% transformer with a VA rating 5 times the drive's input VA rating.
Vinertia	The software regulation reference for V_{bus} during inertia ride through.
Vclose	The threshold to close the pre-charge contactor.
Vopen	The threshold to open the pre-charge contactor.
Vmin	The minimum value of V_{open}.
Voff	The bus voltage below which the switching power supply falls out of regulation.

Table E PF70EC Bus Levels

Class	200/240 VAC	400/480 VAC	600/690 VAC
V_{slew}	1.2V DC	2.4V DC	3.0V DC
$V_{recover}$	V_{mem} – 30V	V_{mem} – 60V	V_{mem} – 75V
V_{close}	V_{mem} – 60V	V_{mem} – 120V	V_{mem} – 150V
$V_{trigger1}$	V_{mem} – 60V	V_{mem} – 120V	V_{mem} – 150V
$V_{trigger2}$	V_{mem} – 90V	V_{mem} – 180V	V_{mem} – 225V
V_{open}	V_{mem} – 90V	V_{mem} – 180V	V_{mem} – 225V
V_{min}	204V DC	407V DC	509V DC
V_{off}	?	300V DC	?



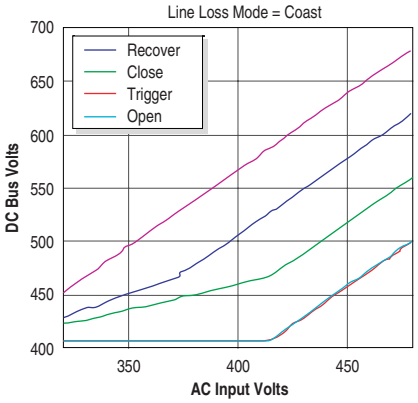
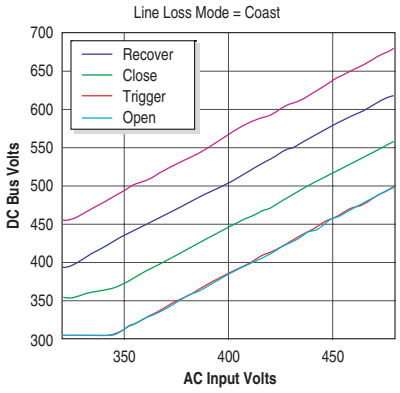
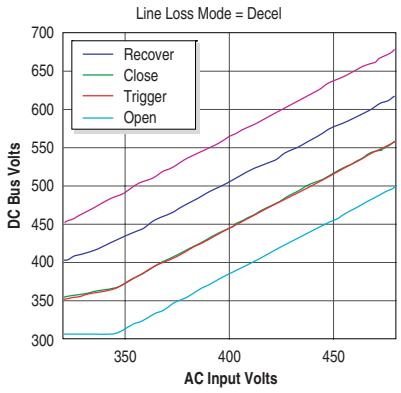


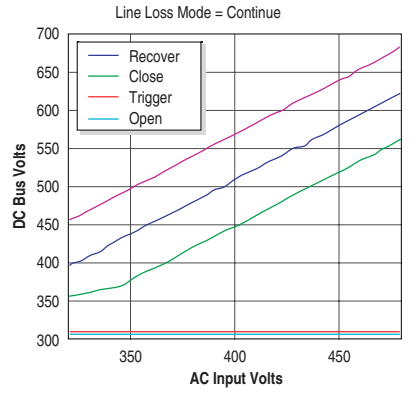
Table F PF700VC Bus Levels

Class	200/240V AC	400/480V AC	600/690V AC
V_{slew}	1.2V DC	2.4V DC	3.0V DC
$V_{recover}$	V_{mem} – 30V	V_{mem} – 60V	V_{mem} – 75V
V_{close}	V_{mem} – 60V	V_{mem} – 120V	V_{mem} – 150V
$V_{trigger1,2}$	V_{mem} – 60V	V_{mem} – 120V	V_{mem} – 150V
$V_{trigger1,3}$	V_{mem} – 90V	V_{mem} – 180V	V_{mem} – 225V
V_{open}	V_{mem} – 90V	V_{mem} – 180V	V_{mem} – 225V
V_{open4}	153V DC	305V DC	382V DC
V_{min}	153V DC	305V DC	382V DC
$V_{off\ 5}$	–	200V DC	–

Note 1:Vtrigger is adjustable, these are the standard values.







Restart after Power Recovery

If a power loss causes the drive to coast and power recovers the drive will return to powering the motor if it is in a “run permit” state. The drive is in a “run permit” state if:

- **3 Wire Mode** - it is not faulted and if all Enable and Not Stop inputs are energized.
- **2 Wire Mode** - it is not faulted and if all Enable, Not Stop, and Run inputs are energized.

Power Loss Actions

The drive is designed to operate at a nominal input voltage. When voltage falls below this nominal value by a significant amount, action can be taken to preserve the bus energy and keep the drive logic alive as long as possible. The drive has three methods of dealing with low bus voltages:

- “Coast” - Disable the drive and allow the motor to coast.
- “Decel” - Decelerate the motor at a rate which will regulate the DC bus until the load’s kinetic energy can no longer power the drive.
- “Continue” - Allow the drive to power the motor down to 50% of the nominal DC bus voltage.

When power loss occurs, the “Power Loss” alarm bit in [Drive Alarm 1] turns on if the respective bit in [Alarm Config 1] is enabled.

If the “Power Loss” bit in [Fault Config 1] is enabled, the drive will fault with a F003-Power Loss Fault when the power loss event exceeds [Power Loss Time].

The drive faults with a F004-UnderVoltage fault if the bus voltage falls below V_{min} and the UnderVoltage bit in [Fault Config 1] is set.

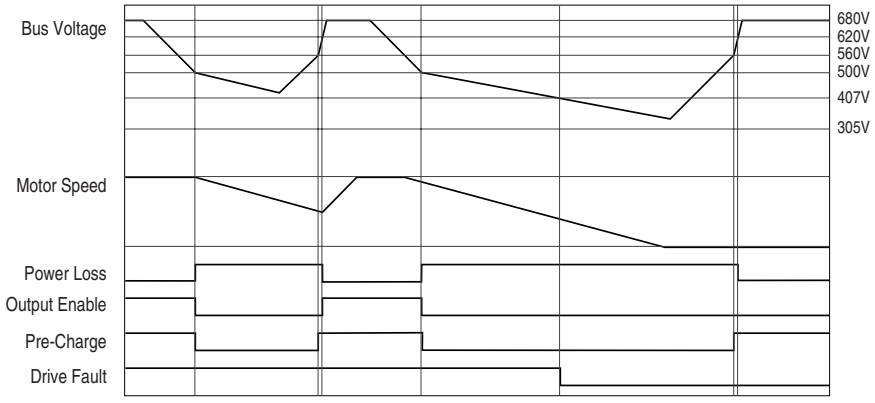
The pre-charge relay opens if the bus voltage drops below V_{open} and closes if the bus voltage rises above V_{close}.

If the bus voltage rises above $V_{recover}$ for 20 ms, the drive determines the power loss is over. The power loss alarm is cleared.

If the drive is in a “Run Permit” state, the reconnect algorithm is run to match the speed of the motor. The drive then accelerates at the programmed rate to the set speed.

Coast

This is the default mode of operation. The drive determines a power loss has occurred if the bus voltage drops below $V_{trigger}$. If the drive is running, the inverter output is disabled and the motor coasts.



480V example shown, see Table F for further information.

Decel

This mode of operation is useful if the mechanical load is high inertia and low friction. By recapturing the mechanical energy, converting it to electrical energy and returning it to the drive, the bus voltage is maintained. As long as there is mechanical energy, the ride through time is extended and the motor remains fully fluxed. If AC input power is restored, the drive can ramp the motor to the correct speed without the need for reconnecting.

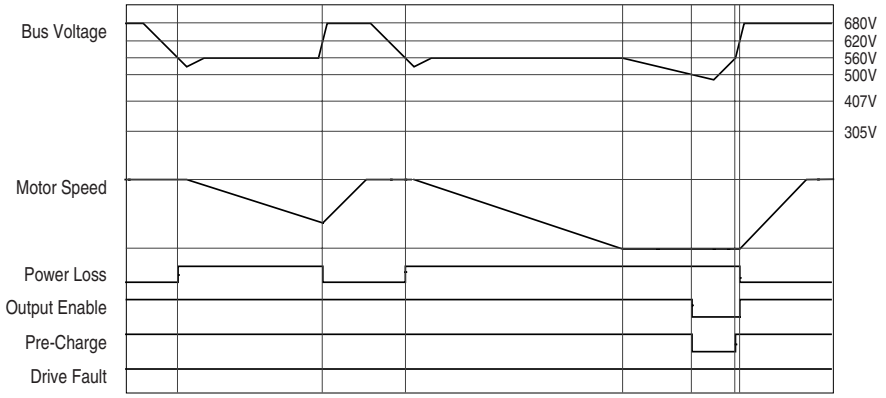
The drive determines a power loss has occurred if the bus voltage drops below $V_{trigger}$.

If the drive is running, the inertia ride through function is activated.

The load is decelerated at the correct rate so that the energy absorbed from the mechanical load regulates the DC bus to the value $V_{inertia}$.

The inverter output is disabled and the motor coasts if the output frequency drops to zero or if the bus voltage drops below V_{open} or if any of the “run permit” inputs are de-energized.

If the drive is still in inertia ride through operation when power returns, the drive immediately accelerates at the programmed rate to the set speed. If the drive is coasting and it is in a “run permit” state, the reconnect algorithm is run to match the speed of the motor. The drive then accelerates at the programmed rate to the set speed.

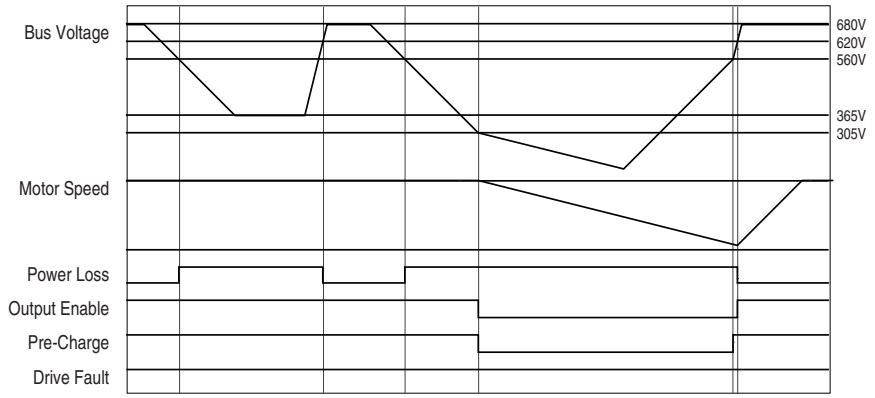


480V example shown, see Table F for further information.

Half Voltage

This mode provides the maximum power ride through. The input voltage can drop to 50% and the drive is still able to supply drive rated current (not drive rated power) to the motor.

ATTENTION: To guard against drive damage, a minimum line impedance must be provided to limit inrush current when the power line recovers. The input impedance should be equal or greater than the equivalent of a 5% transformer with a VA rating 6 times the drive’s input VA rating.



480V example shown, see Table F for further information.

Coast Input and Decel Input *700VC ONLY*

These modes operate similarly to their “non-input” versions, but provide additional ride through time. This is accomplished by early sensing of the power loss via an external device that monitors the power line. This device provides a hardware signal which is connected to the drive through the “pulse” input (because of its high-speed capability). Normally this hardware power loss input will provide a power loss signal before the bus drops to less than V_{open}.

Process PID Loop

70EC *700VC*

The internal PID function provides closed loop process control with proportional and integral control action. The function is designed to be used in applications that require simple control of a process without the use of a separate stand-alone loop controller.

The PID function reads a process variable input to the drive and compares it to a desired setpoint stored in the drive. The algorithm will then adjust the output of the PID regulator, changing drive output frequency to attempt zero error between the process variable and the setpoint.

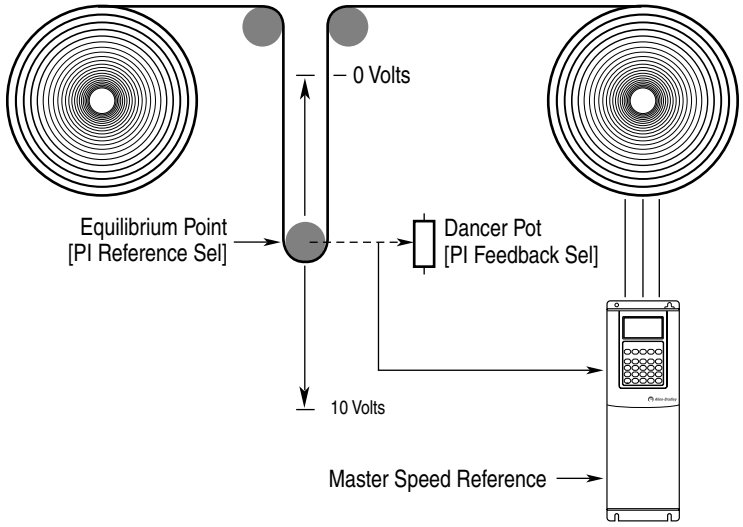
The Process PID can be used to modify the commanded speed or can be used to trim torque. There are two ways the PID Controller can be configured to modify the commanded speed.

- Speed Trim - The PID Output can be added to the master speed reference.
- Exclusive Control - PID can have exclusive control of the commanded speed.

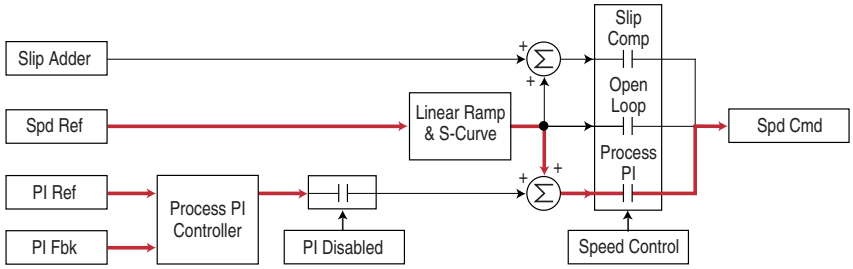
The mode of operation between speed trim, exclusive control, and torque trim is selected in the [PI Configuration] parameter.

Speed Trim Mode

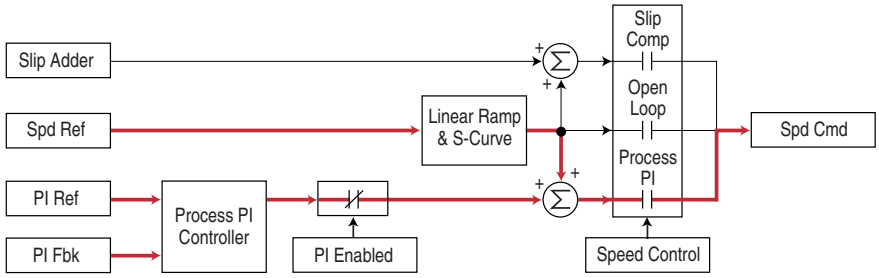
In this mode, the output of the PID regulator is summed with a master speed reference to control the process. This mode is appropriate when the process needs to be controlled tightly and in a stable manner by adding or subtracting small amounts directly to the output frequency (speed). In the following example, the master speed reference sets the wind/unwind speed and the dancer pot signal is used as a PID Feedback to control the tension in the system. An equilibrium point is programmed as PID Setpoint, and as the tension increases or decreases during winding, the master speed is trimmed to compensate and maintain tension near the equilibrium point.



When the PID is disabled the commanded speed is the ramped speed reference.

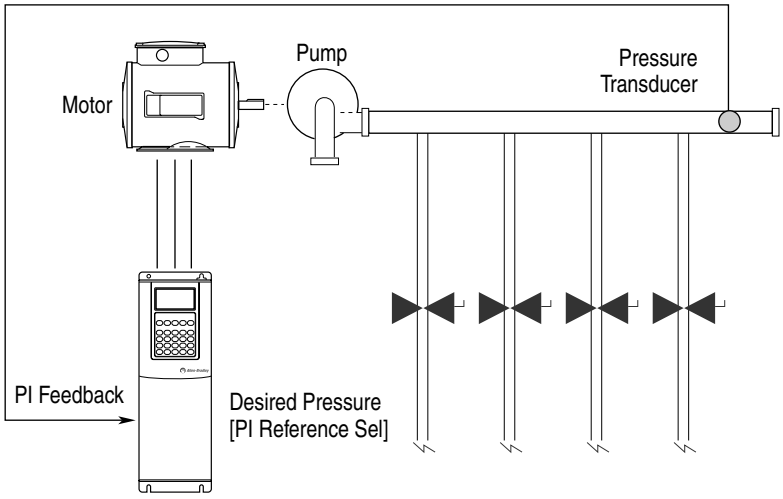


When the PID is enabled, the output of the PID Controller is added to the ramped speed reference.

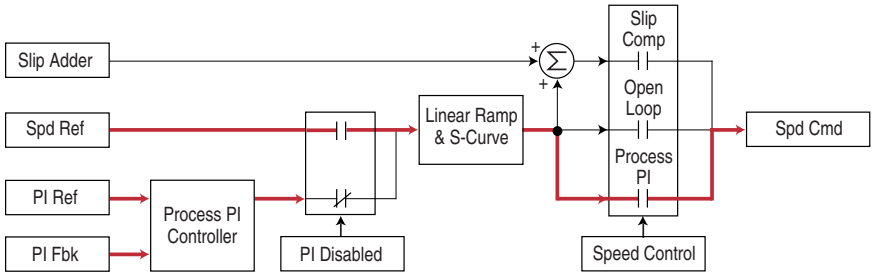


Exclusive Mode

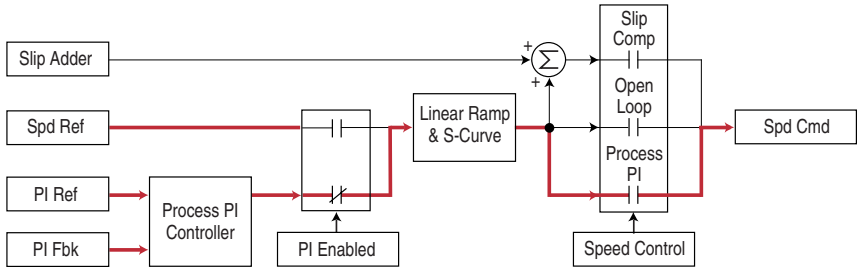
In this mode, the output of PID regulator is the speed reference, and does not “trim” a master speed reference. This mode is appropriate when speed is unimportant and the only thing that matters is satisfying the control loop. In the pumping application example below, the reference or setpoint is the required pressure in the system. The input from the transducer is the PID feedback and changes as the pressure changes. The drive output frequency is then increased or decreased as needed to maintain system pressure regardless of flow changes. With the drive turning the pump at the required speed, the pressure is maintained in the system.



However, when additional valves in the system are opened and the pressure in the system drops, the PID error will alter its output frequency to bring the process back into control. When the PID is disabled the commanded speed is the ramped speed reference.



When the PID is enabled, the speed reference is disconnected and PID Output has exclusive control of the commanded speed, passing through the linear ramp and s-curve.



PID Configuration

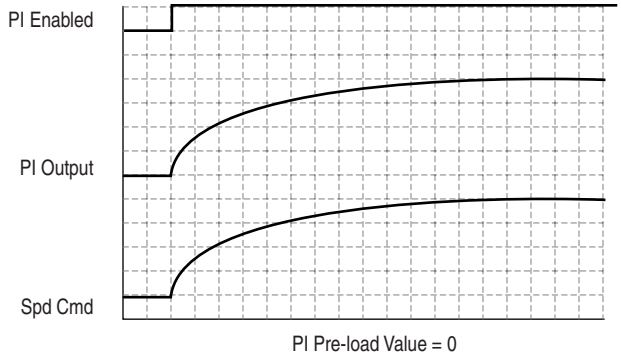
[PI Configuration] is a set of bits that select various modes of operation. The value of this parameter can only be changed while the drive is stopped.

- **Exclusive Mode** - see page 78.
- **Invert Error** - This feature changes the “sign” of the error, creating a decrease in output for increasing error and an increase in output for decreasing error. An example of this might be an HVAC system with thermostat control. In Summer, a rising thermostat reading commands an increase in drive output because cold air is being blown. In Winter, a falling thermostat commands an increase in drive output because warm air is being blown.

  The PID has the option to change the sign of PID Error. This is used when an increase in feedback should cause an increase in output. The option to invert the sign of PID Error is selected in the PID Configuration parameter.
- **Preload Integrator** - This feature allows the PID Output to be stepped to a preload value for better dynamic response when the PID Output is enabled. Refer to the diagram below. If PID is not enabled the PID Integrator may be initialized to the PID Pre-load Value or the current value of the commanded speed. The operation of Preload is selected in the PID Configuration parameter.

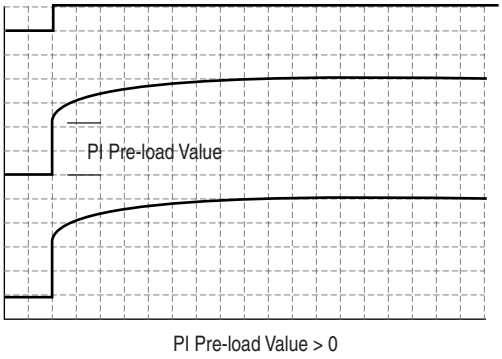
  By default, Pre-load Command is off and the PID Load Value is zero, causing a zero to be loaded into the integrator when the PID is disabled. As shown in diagram A below, when the PID is enabled the PID output will start from zero and regulate to the required level. When PID is enabled with PID Load Value is set to a non-zero value the output begins with a step as shown in Diagram B below. This may result in the PID reaching steady state sooner, however if the step is too large the drive may go into current limit which will extend the acceleration.

Diagram A



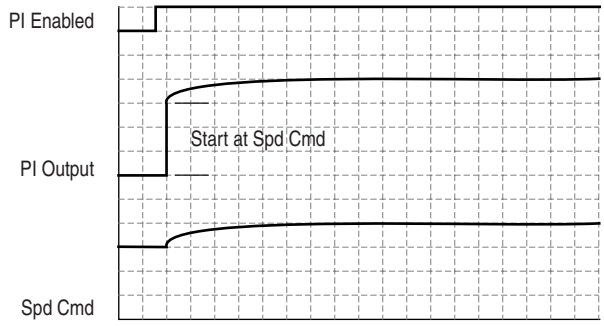
PI Pre-load Value = 0

Diagram B



PI Pre-load Value > 0

Pre-load command may be used when the PID has exclusive control of the commanded speed. With the integrator preset to the commanded speed there is no disturbance in commanded speed when PID is enabled. After PID is enabled the PID output is regulated to the required level.



Pre-load to Command Speed

When the PID is configured to have exclusive control of the commanded speed and the drive is in current limit or voltage limit the integrator is preset to the commanded speed so that it knows where to resume when no longer in limit.

- **Ramp Ref** - The PID Ramp Reference feature is used to provide a smooth transition when the PID is enabled and the PID output is used as a speed trim (not exclusive control). When PID Ramp Reference is selected in the PID Configuration parameter, and PID is disabled, the value used for the PID reference will be the PID feedback. This will cause PID error to be zero. Then when the PID is enabled the value used for the PID reference will ramp to the selected value for PID reference at the selected acceleration or deceleration rate. After the PID reference reaches the selected value the ramp is bypassed until the PID is disabled and enabled again. S-curve is not available as part of the PID linear ramp.

- **Zero Clamp** - This feature limits the possible drive action to one direction only. Output from the drive will be from zero to maximum frequency forward or zero to maximum frequency reverse. This removes the chance of doing a “plugging” type operation as an attempt to bring the error to zero. This bit is active only in trim mode.

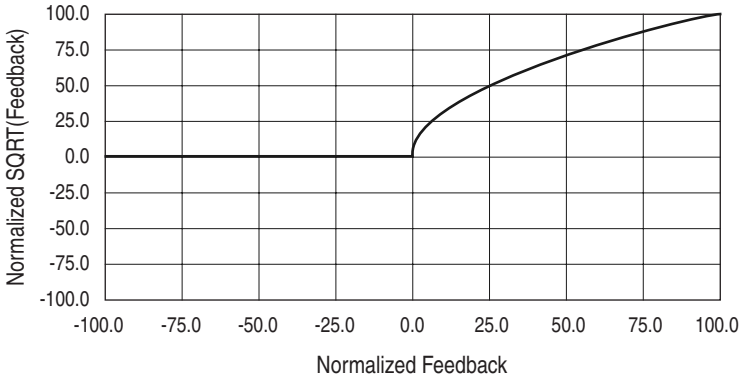
  The PID has the option to limit operation so that the output frequency will always have the same sign as the master speed reference. The zero clamp option is selected in the PID Configuration parameter. Zero clamp is disabled when PID has exclusive control of speed command.

  For example, if master speed reference is +10 Hz and the output of the PID results in a speed adder of –15 Hz, zero clamp would limit the output frequency to not become less than zero. Likewise, if master speed reference is –10 Hz and the output of the PID results in a speed adder of +15 Hz, zero clamp would limit the output frequency to not become greater than zero.

- **Feedback Square Root** - This feature uses the square root of the feedback signal as the PID feedback. This is useful in processes that control pressure, since centrifugal fans and pumps vary pressure with the square of speed.

  The PID has the option to take the square root of the selected feedback signal. This is used to linearize the feedback when the transducer produces the process variable squared. The result of the square root is normalized back to full scale to provide a consistent range of operation. The option to take the square root is selected in the PID Configuration parameter.

- **Stop Mode** - When Stop Mode is set to “1” and a Stop command is issued to the drive, the PID loop will continue to operate during the decel ramp until the PID output becomes more than the master reference. When set to “0,” the drive will disable PID and perform a normal stop. This bit is active in Trim mode only.



- **Anti-Wind Up** - When Anti-Windup is set to “1” the PID loop will automatically prevent the integrator from creating an excessive error that could cause loop instability. The integrator will be automatically controlled without the need for PID Reset or PID Hold inputs.

- **Torque Trim** - When Torque Trim is set to “1” the output of the process PID loop will be added to Torque Reference A and B, instead of being added to the speed reference. Torque Trim is only active in Flux Vector mode.

- ***% of Ref*** - When using Process PID control the output can be selected as percent of the Speed Reference. This works in Speed trim mode only, not in Torque Trim or Exclusive Mode.

  Examples

  % of Ref selected, Speed Reference = 43 Hz, PID Output = 10%, Maximum Frequency = 130 Hz. 4.3 Hz will be added to the final speed reference.

  % of Ref not selected, Speed Reference = 43 Hz, PID Output = 10%, Maximum Frequency = 130 Hz. 13.0 Hz will be added to the final speed reference.

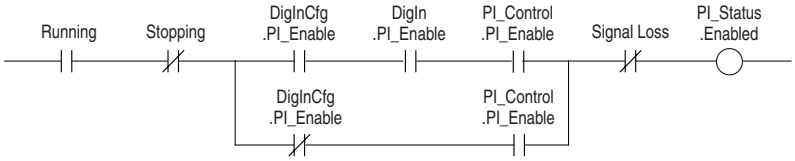
PID Control

[PI Control] is a set of bits to dynamically enable and disable the operation of the process PID controller. When this parameter is interactively written to from a network it must be done through a data link so the values are not written to EEprom.

- **PI Enable** - The PID loop can be enabled/disabled. The Enabled status of the PID loop determines when the PID regulator output is part or all of the commanded speed. The logic evaluated for the PID Enabled status is shown in the following ladder diagram.

  The drive must be in Run before the PID Enabled status can turn on. The PID will remain disabled when the drive is jogged. The PID is disabled when the drive begins a ramp to stop, except when it is in Trim mode and the Stop mode bit in [PI Configuration] is On.

When a digital input is configured as “PI Enable,” the PID Enable bit of [PI Control] must be turned On for the PID loop to become enabled. If a digital input is not configured as “PI Enable” and the PID Enable bit in [PI Control] is turned On, then the PID loop may become enabled. If the PID Enable bit of [PI Control] is left continuously, then the PID may become enabled as soon as the drive goes into Run. If analog input signal loss is detected, the PID loop is disabled.



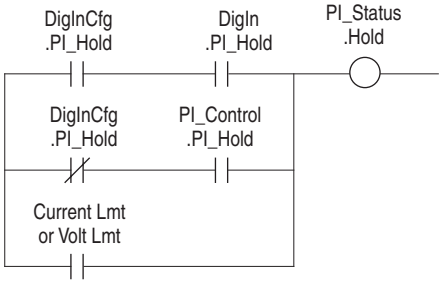
- **PI Hold** - The Process PID Controller has the option to hold the integrator at the current value so if some part of the process is in limit the integrator will maintain the present value to avoid windup in the integrator.

  The logic to hold the integrator at the current value is shown in the following ladder diagram. There are three conditions under which Hold will turn On.

  – If a digital input is configured to provide PID Hold and that digital input is turned on then the PID integrator will stop changing. Note that when a digital input is configured to provide PID Hold that takes precedence over the PID Control parameter.

  – If a digital input is not configured to provide PID Hold and the PID Hold bit in the PID Control parameter is turned On then the PID integrator will stop changing.

  – If the current limit or voltage limit is active then the PID is put into Hold.



- **PI Reset** - This feature holds the output of the integral function at zero. The term “anti windup” is often applied to similar features. It may be used for integrator preloading during transfer and can be used to hold the integrator at zero during “manual mode.”

  For example: a process whose feedback signal is below the reference point, creating error. The drive will increase its output frequency in an attempt to bring the process into control. If, however, the increase in drive output does not zero the error, additional increases in output will be commanded. When the drive reaches programmed Maximum Frequency, it is possible that a significant amount of integral value has been “built up” (windup). This may cause undesirable and sudden operation if the system were switched to manual operation and back. Resetting the integrator eliminates this windup.

PID Status

[PI Status] parameter is a set of bits that indicate the status of the process PID controller

- **Enabled** - The loop is active and controlling the drive output.
- **Hold** - A signal has been issued and the integrator is being held at its current value.
- **Reset** - A signal has been issued and the integrator is being held at zero.
- **In Limit** - The loop output is being clamped at the value set in [PI Upper/Lower Limit].

PID Reference and Feedback

The selection of the source for the reference signal is entered in the PID Reference Select parameter. The selection of the source for the feedback signal is selected in the PID Feedback Select parameter. The reference and feedback have the same limit of possible options.

Options include DPI adapter ports, MOP, preset speeds, analog inputs, pulse input, encoder input and PID setpoint parameter.

The value used for reference is displayed in PID Reference as a read only parameter. The value used for feedback is displayed in PID Feedback as a read only parameter. These displays are active independent of PID Enabled. Full scale is displayed as ±100.00.

PID Reference and Feedback Scaling

The PID reference can be scaled by using [PI Reference Hi] and [PI Reference Lo]. [PI Reference Hi] determines the high value, in percent, for the PID reference. [PI Reference Lo] determines the low value, in percent, for the PID reference.

The PID feedback can be scaled by using [PI Feedback Hi] and [PI Feedback Lo]. [PI Feedback Hi] determines the high value, in percent, for the PID feedback. [PI Feedback Lo] determines the low value, in percent, for the PID feedback.

Example:

The PID reference meter and PID feedback meter should be displayed as positive and negative values. Feedback from our dancer comes into Analog Input 2 as a 0-10V DC signal.

- [PI Reference Sel] = 0 “PI Setpoint”
- [PI Setpoint] = 50%
- [PI Feedback Sel] = 2 “Analog In 2"
- [PI Reference Hi] = 100%
- [PI Reference Lo] = –100%
- [PI Feedback Hi] = 100%
- [PI Feedback Lo] = 0%
- [Analog In 2 Hi] = 10V
- [Analog In 2 Lo] = 0V

PI Feedback Scaling

[Torque Ref A Sel] = “Analog In 1”	
[Analog In 2 Hi] 10V	[PI Feedback Hi] 100%
[Analog In 1 Lo] 0V	[PI Feedback Lo] 0%

Now 5V corresponds to 50% on the PID Feedback, and we will try to maintain a PID setpoint of 50% (5V).

Using Scale Blocks with PID Reference and Feedback

Scale Blocks are included in the Reference and Feedback selections of the Process PID controller. This selects the output of the scale block for use as Reference or Feedback to the Process PID.

PID Setpoint

This parameter can be used as an internal value for the setpoint or reference for the process. If [PI Reference Sel] points to this parameter, the value entered here will become the equilibrium point for the process.

PID Error

The PID Error is then sent to the Proportional and Integral functions, which are summed together.

PID Error Filter

[PI BW Filter] sets up a filter for the PID Error. This is useful in filtering out unwanted signal response, such as noise in the PID loop feedback signal. The filter is a Radians/Second low pass filter.

PID Gains

The [PI Prop Gain], [PI Integral Time] and [PI Deriv Time] parameters determine the response of the PID.

Proportional control (P) adjusts output based on size of the error (larger error = proportionally larger correction). If the error is doubled, then the output of the proportional control is doubled. Conversely, if the error is cut in half then the output of the proportional output will be cut in half. With only proportional control there is always an error, so the feedback and the reference are never equal. [PI Prop Gain] is unit less and defaults to 1.00 for unit gain. With [PI Prop Gain] set to 1.00 and PID Error at 1.00% the PID output will be 1.00% of maximum frequency.

Integral control (I) adjusts the output based on the duration of the error. (The longer the error is present, the harder it tries to correct). The integral control by itself is a ramp output correction. This type of control gives a smoothing effect to the output and will continue to integrate until zero error is achieved. By itself, integral control is slower than many applications require and therefore is combined with proportional control (PI). [PI Integral Time] is entered in seconds. If [PI Integral Time] is set to 2.0 seconds and PI Error is 100.00% the PI output will integrate from 0 to 100.00% in 2.0 seconds.

Derivative Control (D) adjusts the output based on the rate of change of the error and, by itself, tends to be unstable. The faster that the error is changing, the larger change to the output. Derivative control is usually used in torque trim mode and is usually not needed in speed mode.

For example, winders using torque control rely on PD control not PI control. Also, [PI BW Filter] is useful in filtering out unwanted signal response in the PID loop. The filter is a Radians/Second low pass filter.

PID Lower and Upper Limits/ Output Scaling

The output value produced by the PID is displayed as ±100% in [PI Output Meter].

[PI Lower Limit] and [PI Upper Limit] are set as a percentage. In exclusive or speed trim mode, they scale the PID Output to a percentage of [Maximum Freq]. In torque trim mode, they scale the PID Output as a percentage of rated motor torque.

Example

Set the PID lower and Upper limits to ±10% with Maximum Frequency set to 100 Hz. This will allow the PID loop to adjust the output of the drive ±10 Hz.

[PI Upper Limit] must always be greater than [PI Lower Limit].

Once the drive has reached the programmed Lower and Upper PID limits, the integrator stops integrating and no further “windup” is possible.

PID Output Gain

[PI Output Gain] allows additional scaling of the PID loop output.

Example

The application is a velocity controlled winder. As the roll builds up, the output gain can be reduced to allow the dancer signal to be properly reacted to by the PID loop without changing tuning of the PID loop.

PTC Motor Thermistor Input

A PTC (Positive Temperature Coefficient) device (also know as a motor thermistor) embedded in the motor windings, can be monitored by the drive for motor thermal protection.

Configuration and Operation

The PTC is connected to either the dedicated PTC input (PF700VC only) or Analog input 1 along with a pull-up resistor of 3.32k ohms (see the specific product manual for a connection diagram). Note: Analog Input 2 does not support this function.

For connection to analog input 1, the drive can be configured as follows to either fault or alarm:

- [Fault Config 1], parameter 238, Bit 7 = 1 (enabled)
- [Alarm Config 1], parameter 259, Bit 11 = 1 = (enabled)
- Fault and alarm message = “Motor Therm”

For connection to the dedicated PTC input (PF700VC only), the drive can be configured as follows to either fault or alarm:

- [Fault Config 1], parameter 238, Bit 13 = 1 (enabled)
- [Alarm Config 1], parameter 259, Bit 18 = 1 = (enabled)
- Fault and alarm message = “PTC HW”

  Note: If the drive is configured for both alarm and fault, the alarm condition is ignored.

Alarm Operation

An alarm will occur when the PTC resistance increases above 3230 ohms (5V DC), but must decrease below 2153 ohms (4Vdc) for the alarm condition to clear.

Fault Operation

A fault will occur when the PTC resistance increases above 3230 ohms (5V DC), and must be cleared (reset) by a fault clear command (see "Faults" on page 43) after the resistance has decreased below 3230 ohms (5V DC).

The drive will also fault if the PTC voltage drops below 0.2V DC, indicating a shorted PTC.

PWM Frequency

In general, it is best to use the lowest possible PWM (switching) frequency that is acceptable for the application. There are some benefits to increasing the PWM frequency. Refer to Figure 13 and Figure 14. Note the output current at 2 kHz and 4 kHz. The “smoothing” of the current waveform continues as the PWM frequency is increased.

Figure 13 Current at 2 kHz PWM Frequency

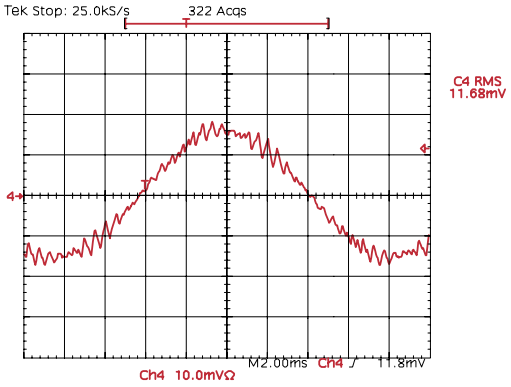
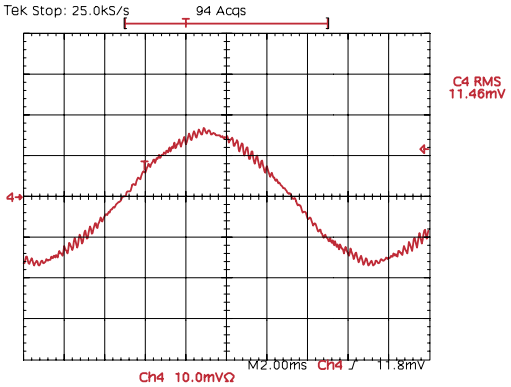


Figure 14 Current at 4 kHz PWM Frequency



Higher PWM frequencies may result in less motor heating and lower audible noise. The decrease in motor heating is considered negligible and motor failure at lower PWM frequencies is very remote. The higher PWM frequency creates less vibration in the motor windings and laminations thus, lower audible noise. This may be desirable in some applications.

Some undesirable effects of higher switching frequencies include derating ambient temperature vs. load characteristics of the drive, higher cable charging currents and higher potential for common mode noise.

See derating guidelines in the Appendix. Also see the Wiring and Grounding document for PWM frequency limitations versus motor cable length.

A very large majority of all drive applications will perform adequately at 2-4 kHz.

Regen Power Limit

The [Regen Power Lim] is programmed as a percentage of the rated power. The mechanical energy that is transformed into electrical power during a deceleration or overhauling load condition is clamped at this level. Without the proper limit, a bus overvoltage may occur.

When using the bus regulator [Regen Power Lim] can be left at factory default, –50%. When using dynamic braking or a regenerative supply, [Regen Power Lim] can be set to the most negative limit possible (–800%). When the user has dynamic braking or regenerative supply, but wishes to limit the power to the dynamic brake or regenerative supply, [Regen Power Lim] can be set to a level specified by the user.

Reset Parameters

Resetting all drive parameters at once (in the active memory being used by the drive) is accomplished by choosing “Reset To Defalts” through the “Memory Storage” area of the HIM main menu. This command can also be executed from [Reset To Defalts], parameter 197 which also offers the following three choices:

- 0, “Ready” - Parameter 197 returns to this value after the reset to defaults is completed.
- 1, “Factory” - All active parameters are reset to values that match the voltage code (e.g. 400V or 480V) that was shipped.
- 2, “Low Voltage” - All active parameters are reset to values that match the lowest voltage within its class (e.g. 400V)
- 3, “High Voltage” - All active parameters are reset to values that match the highest voltage within its class (e.g. 480V)

Reset command 2 would only be used if, for example, a 480V drive (catalog code D) was to be used on a 400V system and motor.

Reset command 3 would only be used if for example, a 400V drive (catalog code C) was to be used on a 480V system and 460V motor.

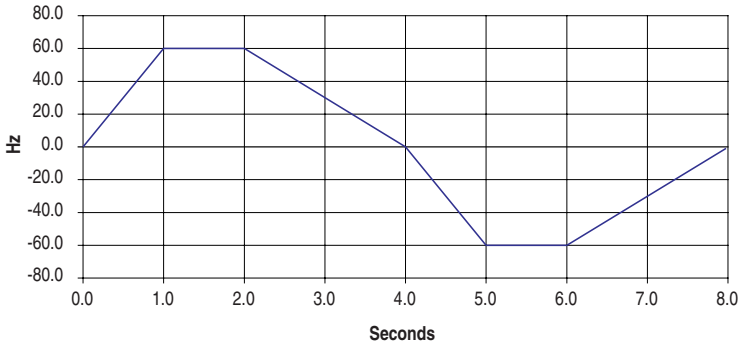
Since reset commands 2 and 3 also reset all drive parameters, they would normally only be used to initialize the drive for the proper voltage prior to making all other parameter settings. Note that the setting for [Voltage Select] is also affected by reset commands 2 and 3, but using [Voltage Select] instead of [Reset To Defalts] will not initialize parameters such as [Motor NP Volts] and [Motor NP Hertz].

When a reset command is executed, it resets all parameters within the active parameter set (normally used by the drive to operate). User Sets (additional memory areas for alternate parameter settings) are unaffected by parameter reset functions. Transferring a default set of parameters into a user set requires a parameter reset command followed by a [Save To User Set] command (see "User Sets" on page 114).

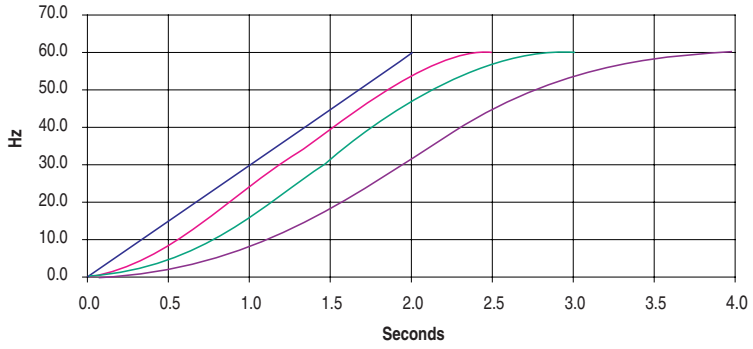
S Curve

The S Curve function provides control of the rate of change of acceleration and deceleration (also known as “jerk”). S Curve helps control the transition from steady state speed to a change in speed. By adjusting the percentage of S Curve applied, the ramp takes the shape of an “S.” This allows a smoother transition and produces less mechanical stress.

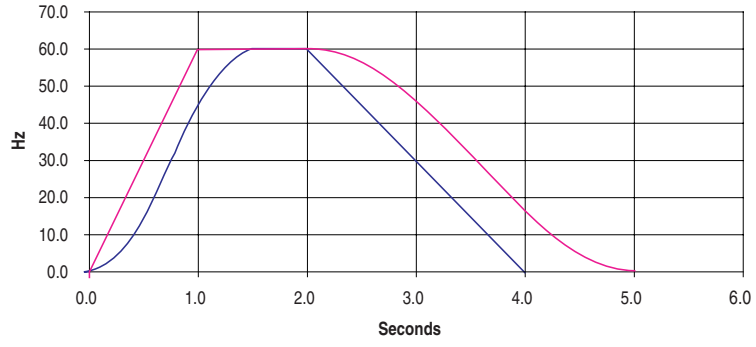
Example with No S Curve



When S Curve is enabled, it adds time to the overall acceleration by a percentage of the programmed acceleration time. This is shown in the curves below, which represent 0%, 25%, 50% and 100% S Curve. Note that half of the “S” is added to beginning and half is added to the end of the ramp.

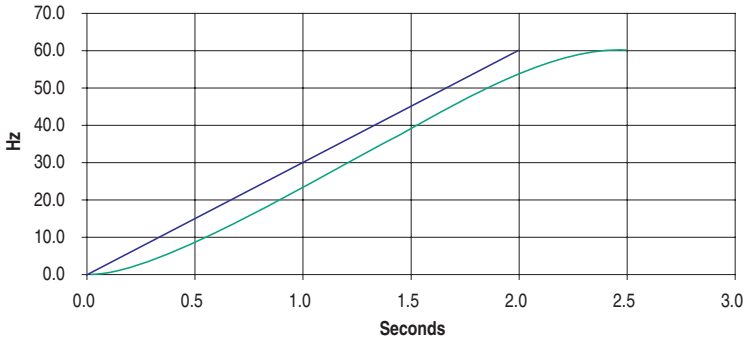


The acceleration and deceleration times are independent but the same S Curve percentage is applied to both as shown in the following example.



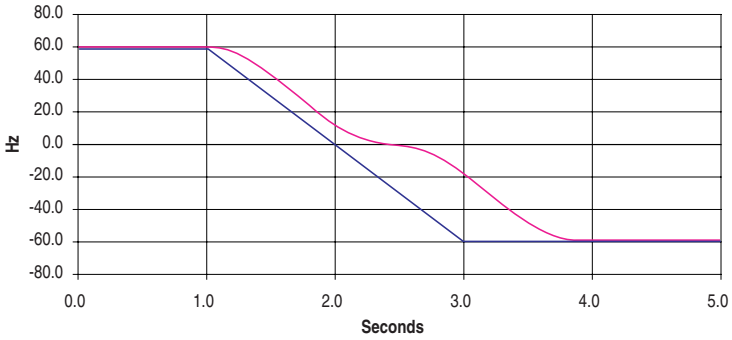
Time to Accelerate

When accelerating from 0 to maximum speed, with maximum speed set to 60 Hz, Ta = 2.0 sec, and S Curve = 25%, acceleration time is extended by 0.5 seconds (2.0 x 25%). When accelerating to only 30 Hz the amount of jerk control (S Curve) is the same, but the extended amount of acceleration time is different.

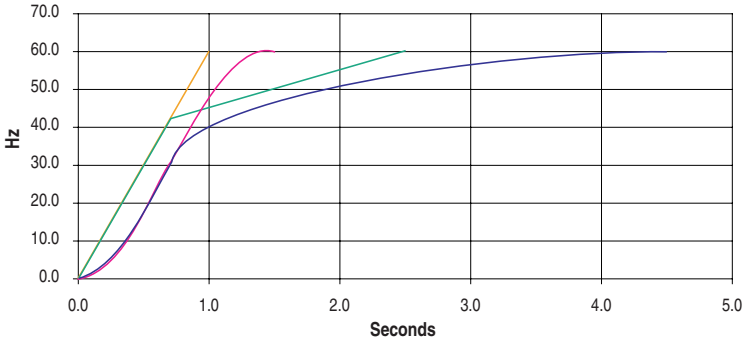


Crossing Zero Speed

When the commanded frequency passes through zero, the frequency will S Curve to zero and then S Curve to the commanded frequency as shown.



The following graph shows an acceleration time of 1.0 second. After 0.75 seconds, the acceleration time is changed to 6.0 seconds. When the acceleration rate is changed, the commanded rate is reduced to match the requested rate based on the initial S Curve calculation. After reaching the new acceleration rate, the S Curve is then changed to be a function of the new acceleration rate.



Safe-Off

Refer to “*DriveGuard Safe-Off User Manual”* publication PFLEX-UM001.

Scale Blocks

See also "Analog Scaling" on page 4 and page 10.

Scale blocks are used to scale a parameter value. [ScaleX In Value] is linked to the parameter that you wish to scale. [ScaleX In Hi] and [ScaleX In Lo] determine the high and low values for the input to the scale block. [ScaleX Out Hi] and [ScaleX Out Lo] determine the corresponding high and low values for the output of the scale block. [ScaleX Out Value] is the resulting output of the scale block.

There are (3) ways to use the output of the scale block:

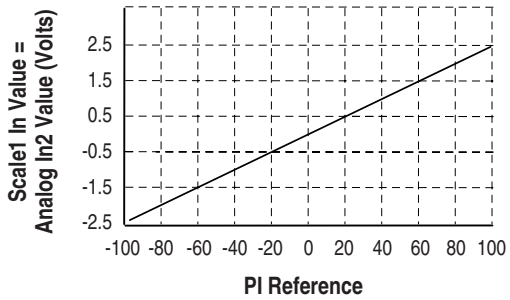
1. A destination parameter can be linked to [ScaleX Out Value].
2. [PI Reference Sel] and [PI Feedback Sel] can also use the output of the scale block by setting them to:
   - 25, “Scale Block1 Out”
   - 26, “Scale Block2 Out”

   Note that when [PI Reference Sel] and [PI Feedback Sel] are set to use the scale blocks, the [Scale X Out Hi] and [Scale x Out Lo] parameters are not active. Instead, [PI Reference Hi] and [PI Reference Lo], or [PI Feedback Hi] and [PI Feedback Lo], determine the scaling for the output of the scale block.
3. [Analog Outx Sel] can be set to:
   - 20, “Scale Block1”
   - 21, “Scale Block2”
   - 22, “Scale Block3”
   - 23, “Scale Block4”

   Note that when the Analog Outputs are set to use the scale blocks, the [Scale x Out Hi] and [ScaleX Out Lo] parameters are not active. Instead, [Analog OutX Hi] and [Analog OutX Lo] determine the scaling for the output of the scale block. See "Analog Outputs" on page 10.

Example Configuration

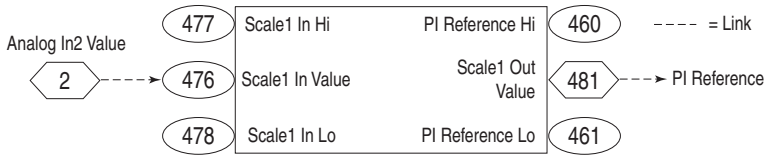
In this configuration Analog In 2 is a –10V to +10V signal which corresponds to –800% to +800% motor torque from another drive. We want to use the –200% to +200% range (–2.5V to +2.5V) of that motor torque and correspond it to –100% to +100% of the PI Reference.



Parameter Settings

Parameter	Value	Description
[Scale 1 In Hi]	2.5 V	2.5 V = 200% torque from other drive
[Scale 1 In Lo]	–2.5V	–2.5 V = –200% torque from other drive
[PI Reference Sel]	25, Scale Block1 Out	The PI Reference becomes the output of the scale block
[PI Reference Hi]	100 %	100% PI Reference corresponds to 200% torque from other drive
[PI Reference Lo]	–100 %	–100% PI Reference corresponds to –200% torque from other drive

Parameter Links



Destination Parameter	Source Parameter	Description
[Scale1 In Value]	[Analog In2 Value]	Scaling Analog In 2 value

Security

This feature provides write access protection for individual communication ports in a drive. In addition, the following drive peripherals and software tools support this security technology.

Communication Peripherals

- 20-COMM-E EtherNet/IP v2.002 (or higher)
- 20-COMM-C/-Q ControlNet v2.001 (or higher)
- 20-COMM-D DeviceNet v2.001 (or higher)
- 20-COMM-S DF1 v1.003 (or higher)

Software Tools

- DriveExplorer v4.04 (or higher)
- DriveTools SP v4.01 (or higher)

By default, every DPI port in the drive is configured to allow write access. For additional information on DPI port locations and their assignments, refer to “HIM Overview” in Appendix B of the User Manual.

To change write access on an individual DPI port, change the bit setting of the associated port in [Write Mask Cfg], parameter 596.

- Bit 0 = Host (drive)
- Bit 1 = DPI Port 1
- Bit 2 = DPI Port 2
- Bit 3 = DPI Port 3
- Bit 4 = DPI Port 4 (PF700VC only)
- Bit 5 = DPI Port 5

  Bit value of 0 = masked (read only access)

  Bit value of 1 = not masked (read/write access)

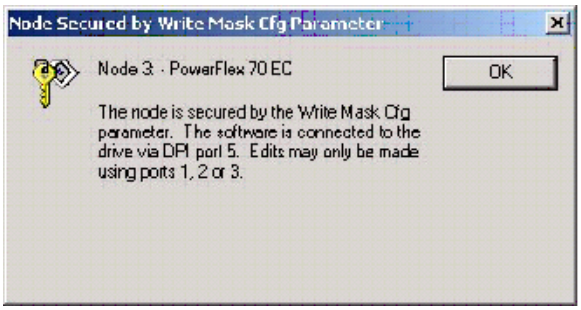
Any changes to [Write Mask Cfg] will not take effect until one of the following three events occur:

- Power is removed and reapplied.
- A drive reset (not reset to defaults) is performed.
- [Write Mask Act], parameter 597, bit 15 transitions from “1” to “0.”

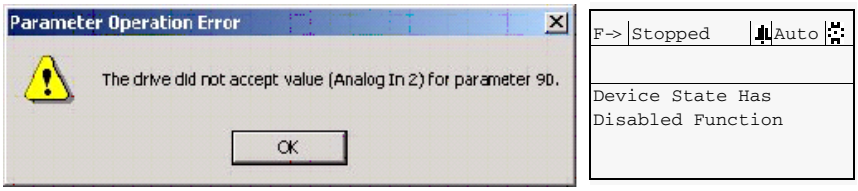
The status of a port’s write access may be verified at [Write Mask Act]. For example, to verify that write access was disabled on “DPI Port 1”, bit 1 should equal bit 1 in [Write Mask Cfg].

The port that is being used to make security changes (e.g. if using a network adapter connected to Port 5), can only change other ports (not itself) to “Read Only.” This is to prevent the complete lockout of a drive with no future way to regain write access.

The figure on the left shows how DriveExplorer will respond when connected to a PowerFlex 70 EC drive that has security enabled on DPI Port 5. The “ ” icon will also appear in the program window to indicate that the adapter you are communicating through has its port write access disabled. The figure on the right shows how a HIM will respond when a write is attempted on a port that does not have write privileges.


Node Secured by Write Mask Cfg Parameter
Node 3 - PowerFlex 70 EC
OK
The node is secured by the Write Mask Cfg parameter. The software is connected to the drive via DPI port 5. Edits may only be made using ports 1, 2 or 3.
F-> Stopped Auto
Security Enabled
Access Denied

When connected to a port configured for “Read Only” with programming tools that do not have security functionality, errors will occur for any write attempt. Examples of such tools are HIMs with older firmware, earlier versions of Drive Tools or Drive Explorer, and third party software. See the following example messages when using tools that do not support the security function:


Parameter Operation Error
The drive did not accept value (Analog In 2) for parameter 90.
OK
F-> Stopped Auto
Device State Has
Disabled Function

Shear Pin

70EC 700VC

As a default, the drive will fold back when the output current exceeds the current limit level. However, the shear pin feature can be used to instantly fault the drive when output current exceeds a programmed amount. Additionally, the drive can be programmed to ignore this condition during acceleration and deceleration which often requires current that would otherwise cause a shear pin fault. Also, the condition can be completely ignored for a programmable amount of time. There are situations where a fast acceleration of the motor will cause the drive to output current to the motor near or at the current limit value for shear pin and fault the drive while in acceleration. To avoid this condition set bit 11 in parameter 238 to "1". Using bit 11 in parameter 238 without bit 4 being "1" has no effect. In addition a shear pin time needs to be set in parameter 189. This will allow current limit for [shear pin time] before faulting the drive.

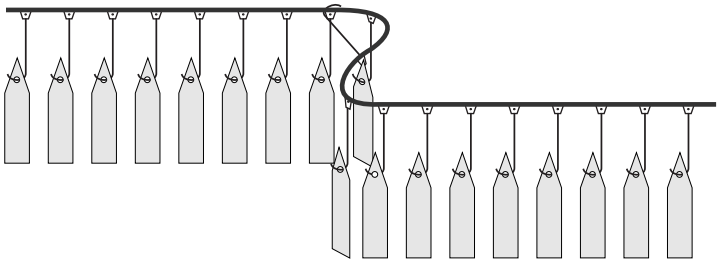
A unique fault (Shear Pin, F63) will be generated if the function is activated and the condition occurs.

Configuration

- P238 [Fault Config 1], bit 4 (Shear Pin) = "1" - this enables the shear pin fault).
- P238 [Fault Config 1], bit 11 (ShearPNo Acc) = "1" - this enables the ignore feature during accelerations.
- P189 [Shear Pin Time] = desired amount of time to ignore the shear pin condition before a fault occurs (e.g. 0.5 sec).
- P147 [Current Lmt Sel] = "Cur Lim Val" - specifies the source of the current limit level. Can also com from analog inputs.
- P148 [Current Lmt Val] = desired value for current limit and shear pin fault (e.g. 15 amps).

Application Example

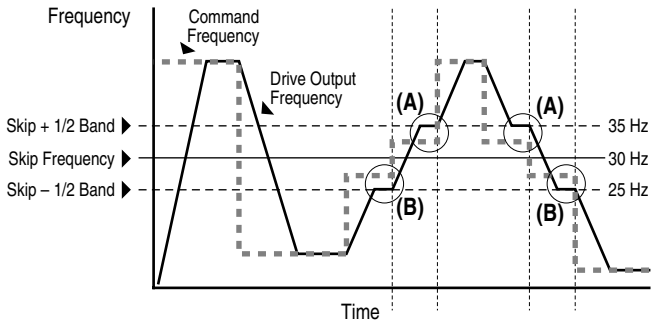
By programming the Shear Pin feature, the drive will fault, stopping the excess torque before mechanical damage occurs.



Skip Frequency

70EC 700VC

Figure 15 Skip Frequency

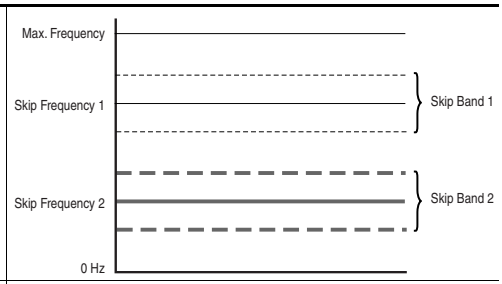
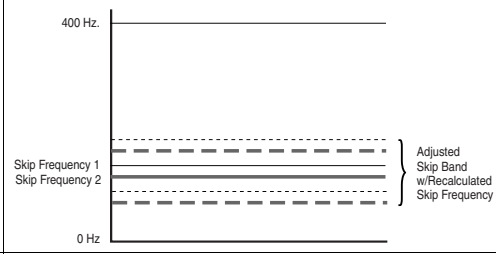
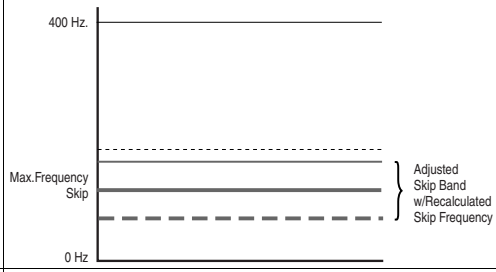
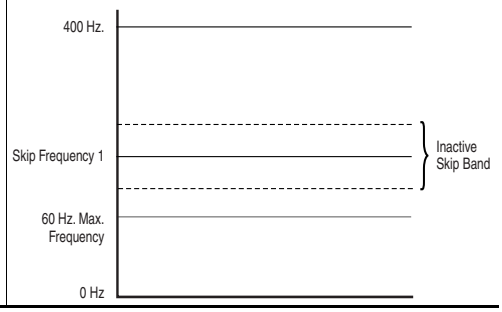


Some machines may have a resonant operating frequency (vibration speed) that is undesirable or could cause equipment damage. To guard against continuous operation at one or more resonant points, parameters 084-086, ([Skip Frequency 1-3]) can be programmed.

The value programmed into a skip frequency parameter, sets the center point for an entire “skip band” of frequencies. The width of the band (range of frequency around the center point) is determined by [Skip Freq Band], parameter 87. The range is split, half above and half below the skip frequency parameter.

If the commanded frequency is greater than or equal to the skip (center) frequency and less than or equal to the high value of the band (skip plus 1/2 band), the drive will set the output frequency to the high value of the band. See (A) in Figure 15.

If the commanded frequency is less than the skip (center) frequency and greater than or equal to the low value of the band (skip minus 1/2 band), the drive will set the output frequency to the low value of the band. See (C) in Figure 15.

Skip Frequency Examples	
The skip frequency will have hysteresis so the output does not toggle between high and low values. Three distinct bands can be programmed. If none of the skip bands touch or overlap, each band has its own high/low limit.	
If skip bands overlap or touch, the center frequency is recalculated based on the highest and lowest band values.	
If a skip band(s) extend beyond the max frequency limits, the highest band value will be clamped at the max frequency limit. The center frequency is recalculated based on the highest and lowest band values.	
If the band is outside the limits, the skip band is inactive.	

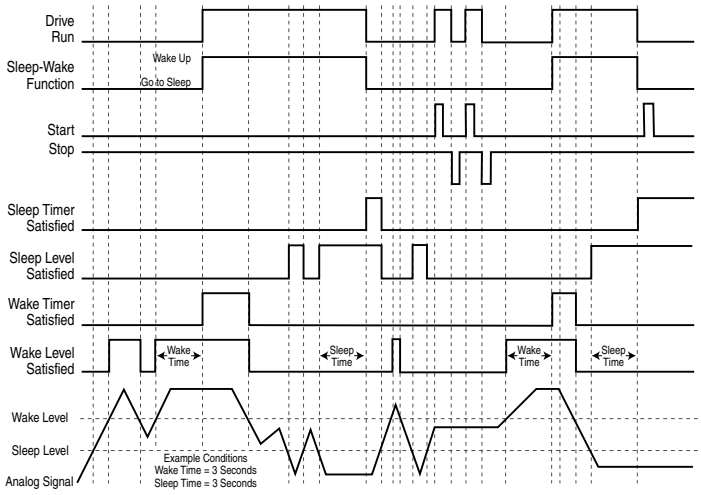
Acceleration and deceleration are not affected by the skip frequencies. Normal accel/decel will proceed through the band.

Sleep Mode

The purpose of the Sleep-Wake function is to **Start** (wake) the drive when an analog signal is greater than or equal to the specified [Wake Level], and **Stop** (sleep) the drive when an analog signal is less than or equal to the specified [Sleep Level]. Setting [Sleep-Wake Mode] to “Direct” enables the sleep-wake function to work as described.

An “Invert” mode also exists, which changes the logic so that an analog value less than or equal to [Wake Level] starts the drive and an analog value greater than or equal to [Sleep Level] stops the drive.

Sleep/Wake Operation



Requirements

In addition to enabling the sleep function with [Sleep-Wake Mode], at least one of the following assignments **must** be made to a digital input: Enable, Stop-CF, Run, Run Fwd or Run Rev, and the input must be closed. All normal Start Permissives must also be satisfied (Not Stop, Enable, Not Fault, Not Alarm, etc.).

Conditions to Start/Restart

ATTENTION: Enabling the Sleep-Wake function can cause unexpected machine operation during the Wake mode. Equipment damage and/or personal injury can result if this parameter is used in an inappropriate application. Do Not use this function without considering the table below and applicable local, national & international codes, standards, regulations or industry guidelines.

Table G Conditions Required to Start Drive(1)(2)(3)

Input	After Power-Up	After a Drive Fault		After a Stop Command
		Reset by Stop-CF, HIM or TB	*Reset by Clear Faults (TB)*	*HIM or TB*
Stop	Stop Closed Wake Signal	Stop Closed Wake Signal New Start or Run Cmd.(4)	Stop Closed Wake Signal	Stop Closed Analog Sig. > Sleep Level(6) New Start or Run Cmd.(4)
Enable	Enable Closed Wake Signal(4)	Enable Closed Wake Signal New Start or Run Cmd.(4)	Enable Closed Wake Signal	Enable Closed Analog Sig. > Sleep Level (6) New Start or Run Cmd.(4)
Run Run For. Run Rev.	Run Closed Wake Signal	New Run Cmd.(5) Wake Signal	Run Closed Wake Signal	New Run Cmd.(5) Wake Signal

(1) When power is cycled, if all conditions are present after power is restored, restart will occur.

(2) If all conditions are present when [Sleep-Wake Mode] is “enabled,” the drive will start.

(3) The active speed reference is determined as explained in the User Manual. The Sleep/Wake function and the speed reference may be assigned to the same input.

(4) Command must be issued from HIM, TB or network.

(5) Run Command must be cycled.

(6) Signal does not need to be greater than wake level.

Normal operation will require that [Wake Level] be set greater than or equal to [Sleep Level]. However, there are no limits that prevent the parameter settings from crossing, but the drive will not start until such settings are corrected. These levels are programmable while the drive is running. If [Sleep Level] is made greater than [Wake Level] while the drive is running, the drive will continue to run as long as the analog input remains at a level that doesn’t trigger the sleep condition. Once the drive goes to sleep in this situation, it will not be allowed to restart until the level settings are corrected (increase wake, or decrease sleep). If however, the levels are corrected prior to the drive going to sleep, normal Sleep/Wake operation will continue.

Timers

[Wake Time]
[Sleep Time]

Timers will determine the length of time required for Sleep/Wake levels to produce true functions. These timers will start counting when the Sleep/Wake levels are satisfied and will count in the opposite direction whenever the respective level is dissatisfied. If the timer counts all the way to the user specified time, it creates an edge to toggle the Sleep/Wake function to the respective condition (sleep or wake). On power up, timers are initialized to the state that does not permit a start condition. When the analog signal satisfies the level requirement, the timers start counting.

Interactive functions

Separate start commands are also honored (including a digital input “start”), but only when the sleep timer is not satisfied. Once the sleep timer times out, the sleep function acts as a continuous stop. There are two exceptions to this, which will ignore the Sleep/Wake function:

1. When a device is commanding “local” control
2. When a jog command is being issued.

When a device is commanding “local” control, the port that is commanding it has exclusive start control (in addition to ref select), essentially overriding the Sleep/Wake function, and allowing the drive to run in the presence of a sleep situation. This holds true even for the case of Port 0, where a digital input start or run will be able to override a sleep situation.

Sleep/Wake Sources

The analog source for the sleep-wake function can be any analog input, whether it is being used for another function or not. Configuring the sleep-wake source is done through [Sleep-Wake Ref]. Also, [Analog In X Hi] and [Analog In X Lo] parameters have no affect on the function. However, the factory calibrated result is used. In addition, the absolute value of the calibrated result is used, thus making the function useful for bipolar direction applications. The analog in loss function is unaffected and therefore operational with the Sleep-Wake function, but not tied to the sleep or wake levels.

Speed Reference

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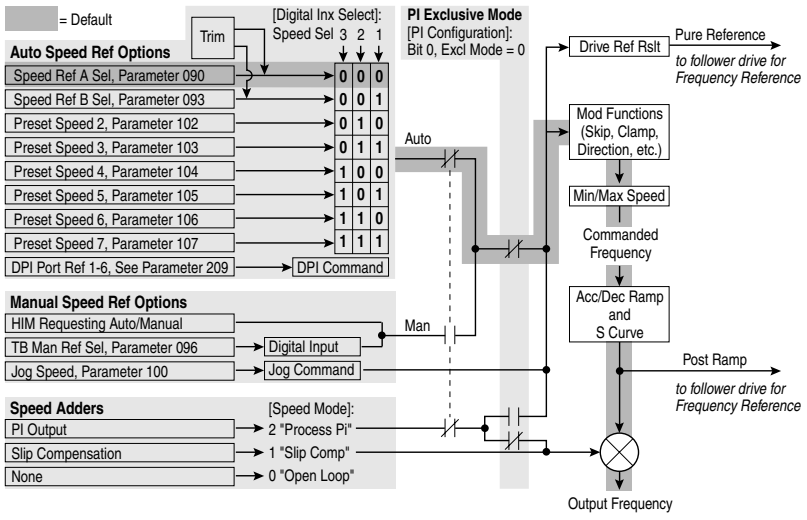
The speed reference can come from a variety of sources that can be selected through digital inputs or via bit manipulation of the Network Logic Command Word.

- HIM (local or remote)
- Analog Input
- Preset Speed Parameter
- Jog Speed Parameter
- Network Communications
- Process PI Loop
- MOP

Figure 16 Speed Reference Selection



Important: Speed Reference A is the normal speed reference used. To choose a source for this reference, make a selection in [Speed Ref A Sel], parameter 90. Also, when the network (Logic Command Word) is used to choose a speed reference, refer to Appendix A in the PowerFlex 70 or 700 User Manual for detailed operation.

Network Reference

When a network (communication adapter) is selected as the speed reference, a 16 bit word is used as the speed reference. If [Direction Mode], parameter 190 is set to “Bipolar”, the most significant bit (MSB) is used for direction control. Otherwise, the MSB is ignored. The remaining 15 bits (32767 decimal) provide the magnitude.

By default, the maximum network value is scaled to [Maximum Freq], parameter 55. Using the default value of 130 Hz results in the following scaling relationship:

Example 1:Maximum Network Reference = Maximum Frequency

- [DIP Ref Select], parameter 298 = “Max Freq”
- [Maximum Freq], parameter 55 = 130 Hz
- [Maximum Speed], parameter 82 = 60 Hz
- Speed Reference = (Network value/Maximum Freq) x 32767

When full speed (60 Hz) is desired, the following network value must be sent:

- (60/130) x 32767 = 15123

[Maximum Freq], parameter 55 *cannot always simply be changed to 60 Hz* so that the maximum network value is equal to 60 Hz. An internal control rule between Maximum Frequency, Overspeed Limit, and Maximum Speed usually prevents such a change. However, [DPI Ref Select], parameter 298 allows a setting which changes the scaling to Maximum Speed instead of Maximum Frequency, as shown in the following example:

Example 2: Maximum Network Reference = Maximum Speed

- [DIP Ref Select], parameter 298 = “Max Speed”
- [Maximum Freq], parameter 55 = 130 Hz
- [Maximum Speed], parameter 82 = 60 Hz

Speed Reference = (Network value/Maximum Speed) x 32767

When full speed (60 Hz) is desired, the following network value must be sent:

(60/60) x 32767 = 32767

Jog

When the drive is not running, pressing the HIM Jog button or a programmed Jog digital input will cause the drive to jog at a separately programmed jog reference. This speed reference value is entered in [Jog Speed], parameter 100.

Scaling of an Analog Speed Reference

Refer to "Analog Inputs" on page 4.

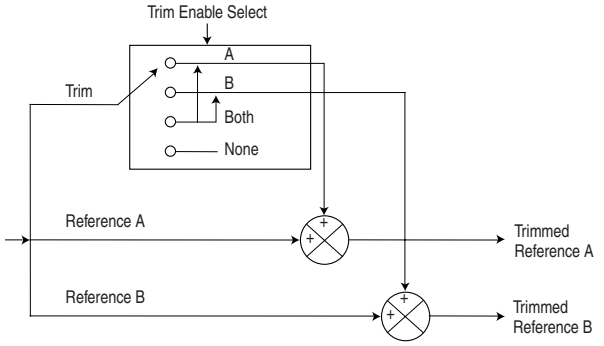
Polarity

The reference can be selected as either unipolar or bipolar. Unipolar is limited to positive values and supplies only the speed reference. Bipolar supplies both the speed reference AND the direction command: + signals = forward direction and – signals = reverse direction.

Trim

If the speed reference is coming from the source specified in [Speed Ref A Sel] or [Speed Ref B Sel], it can be trimmed by variable amount.

Figure 17 Trim



The source of the trim signal is selected through [Trim In Sel], parameter 117. All selections for [Speed Ref A] and [Speed Ref B] are also valid choices for a trim source. In addition, [Trim % Setpoint], parameter 116 is also available as a trim source.

[Trim Out Select], parameter 118 configures which speed reference(s) will be trimmed and whether the trim signal is either added as an absolute fixed amount over the speed range, or a percent of the speed reference:

- Bit 0, “Trim Ref A” 0 = not trimmed, 1 = trimmed
- Bit 1, “Trim Ref B” 0 = not trimmed, 1 = trimmed
- Bit 2, “Add or %”

  0 = A specific value of the trim source provides an absolute amount of trim (equal to a percent of [Maximum Speed]) over entire speed range.

  1 = A specific value of the trim source provides a percent amount of trim (equal to a percent of the speed reference) over the entire speed range.

If the trim source is an analog input, [Trim Hi] and [Trim Lo], parameters 119 & 120 scale the trim signal in units of either Hz or %, dependent on whether or not “Add” or “%” mode is selected.

If the trim source is [Trim % Setpoint], its units (Hz or %) are also dependent on whether or not “Add” or “%” mode is selected.

Example 1: “Percent” mode:

– [Maximum Speed] = 60
– [Trim In Select} = 2 “Analog In 2"
– [Trim Out Select], bit 0 “Speed Ref A” = 1
– [Trim Out Select], bit 2 “Add or %” = 1 (% mode)

If the speed reference = 20 Hz, and Analog Input 2 = 1V, the resulting trim will be 20 Hz x 10% = 2.0 Hz, which when added to the speed reference is 20Hz. As the speed reference changes, the absolute amount of trim also changes since it is a percent of the speed reference For example, if the speed reference changes to 40 Hz, the amount of trim added is 40 Hz x 10% = 4.0 Hz, and so on.

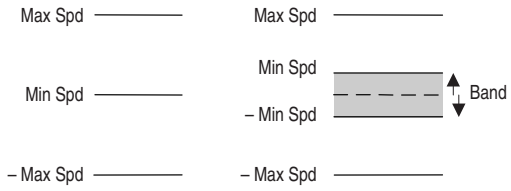
Example 2: “Add” mode:

– [Maximum Speed] = 60
– [Trim In Select] = 2 “Analog In 2"
– [Trim Out Select], bit 0 “Speed Ref A” = 1
– [Trim Out Select], bit 2 “Add or % Ref” = 0 (Add mode)

If the speed reference = 20 Hz, and Analog Input 2 = 10V, the resulting trim will be 60 Hz x 20% = 12 Hz, which is added to the speed reference even as the speed reference changes. For example, if the speed reference changes to 40Hz, the absolute amount of trim added remains equal to 60 Hz x 10% = 4.0 Hz, and so on. In this case a different absolute amount of trim would require a change at analog input 2.

Min/Max Speed

Maximum and minimum speed limits are applied to the reference. These limits apply to the positive and negative references. The minimum speed limits will create a band that the drive will not run continuously within, but will ramp through. This is due to the positive and negative minimum speeds. If the reference is positive and less than the positive minimum, it is set to the positive minimum. If the reference is negative and greater than negative minimum, it is set to the negative minimum. If the minimum is not 0, hysteresis is applied at 0 to prevent bouncing between positive and negative minimums. See below.



Maximum frequency

The maximum frequency defines the maximum reference frequency. The actual output frequency may be greater as a result of slip compensation and other types of regulation.

Speed Regulation

The drive achieves speed regulation by adjusting the output frequency to compensate for load changes.

The [Feedback Select] parameter selects the speed regulation method as follows:

- Open Loop
- Slip Compensation
- Encoder
- Simulator

Open Loop

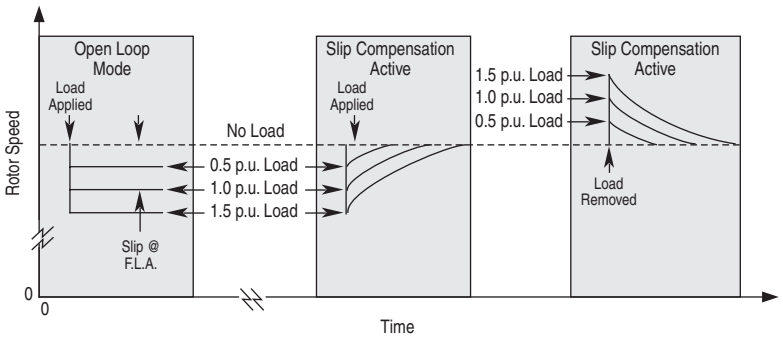
As the load on an induction motor increases, the rotor shaft speed decreases, creating slip (and therefore torque) to drive the load. In open loop mode, motor speed will be dependent on load changes and the drive will make no attempt to compensate. The amount of speed change (slip) from no load to full load is a function of motor design, but is typically 3% of base synchronous speed (e.g. 3% of 1800 RPM = 54 RPM). This “slip” is constant across the speed range.

Slip Compensation

When slip compensation mode is selected, the drive automatically adds the appropriate amount of output frequency to maintain a consistent motor speed independent of load. During drive commissioning [Slip RPM @ FLA] is set based on entered motor nameplate information. This parameter may be adjusted to provide more or less slip.

See Figure 18 for a comparison of operation with and without slip compensation. This shows that over time, slip compensation will correct for changes in load (curved lines). In contrast, open loop operation shows that no correction is made based on load.

Figure 18 Rotor Speed with/without Slip Compensation

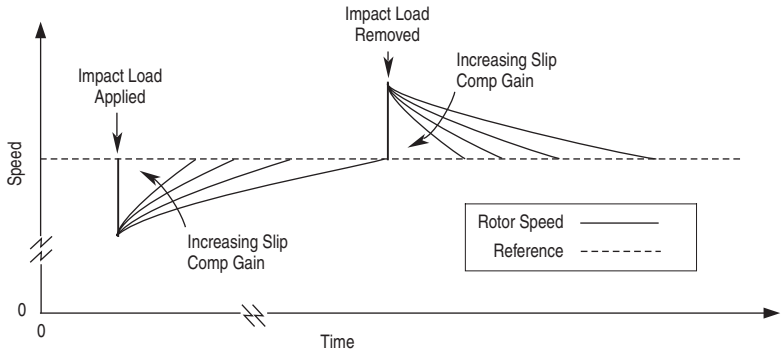


Internally, the drive converts the rated slip in RPM to rated slip in frequency. To more accurately determine the rated slip frequency in hertz, an estimate of flux current is necessary. This parameter is either a default value based on motor nameplate data or the auto tune value. The drive scales the amount of slip compensation to the motor rated current. The amount of slip frequency added to the frequency command is then scaled by the sensed torque current (indirect measurement of the load) and displayed.

Slip compensation also affects the dynamic speed accuracy (ability to maintain speed during “shock” loading) as illustrated in Figure 19. Initially, the motor is operating at some speed and no load. At some time later, an impact load is applied and the rotor speed decreases as a function of load and inertia. And finally, the impact load is removed and the rotor speed increases momentarily until the slip compensation is reduced based on the applied load.

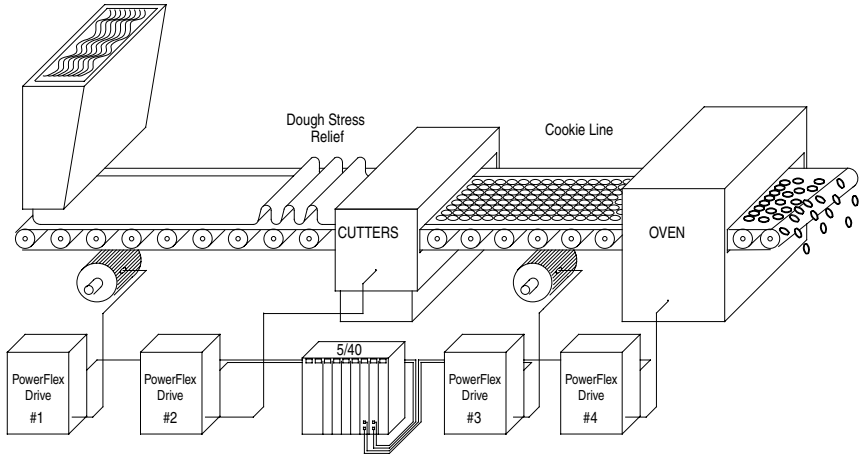
The responsiveness to an impact load can be adjusted through [Slip Comp Gain]; however too large of a gain can cause unstable operation and overshoot.

Figure 19 Rotor Speed Response Due to Impact Load and Slip Com Gain



Application Example - Baking Line

The diagram below shows a typical application for the Slip Compensation feature. The PLC controls the frequency reference for all four of the drives. Drive #1 and Drive #3 control the speed of the belt conveyor. Slip compensation will be used to maintain the RPM independent of load changes caused by the cutter or dough feed. By maintaining the required RPM, the baking time remains constant and therefore the end product is consistent.



Encoder Feedback (Closed Loop)

An encoder offers the best performance for both speed and torque regulation applications, providing high bandwidth response, tight speed regulation, torque regulation, and very low speed operation (less than 1/120th of base motor speed).

- [Motor Fdbk Type] selects the type of encoder:
  - "Quadrature" – dual channel.
  - "Quad Check" – dual channel and detects loss of encoder signal when using differential inputs.
  - "Single Chan" – pulse type, single channel.
  - "Single Check" – pulse type, single channel and detects loss of encoder signal when using differential inputs.
- [Encoder PPR] sets the number of encoder pulses per revolution.
- [Enc Pos Feedback] displays the raw encoder count. For single channel encoders, this count will increase (per rev.) by the amount in [Encoder PPR]. For quadrature encoders this count will increase by 4 times the amount defined in [Encoder PPR].

In closed loop mode, the drive uses proportional and integral gains to adjust the torque reference that is sent to the motor and produces a high bandwidth response to speed command and load changes.

Integral Gain

The integral gain block outputs a torque command relative to the error integrated over a period of time.

[Ki Speed Loop] sets the integral gain of the speed regulator. Its value is automatically calculated based on the bandwidth setting in [Speed Desired BW]. Integral gain may be manually adjusted by setting [Speed Desired BW] to a value of zero. Units are (per unit torque/sec) / (per unit speed). For example, when [Ki Speed Loop] is 50 and the speed error is 1%, the integral output will integrate from 0 to 50% motor rated torque in 1 second.

Proportional Gain

The proportional gain determines how much of a speed error occurs during a load transient.

[Kp Speed Loop] sets the proportional gain of the speed regulator. Its value is automatically calculated based on the bandwidth setting in [Speed Desired BW]. Proportional gain may be manually adjusted by setting [Speed Desired BW] to a value of zero. Units are (per unit torque) / (per unit speed). For example, when [Kp Speed Loop] is 20, the proportional gain block will output 20% motor rated torque for every 1% error of motor rated speed.

Feed Forward Gain

The first section of the PI regulator is the feed forward block. [Kf Speed Loop] allows the speed regulator to be dampened during speed changes. To reduce speed overshoot, reduce the value of [Kf Speed Loop]. During auto-tune, the feed forward is left open (no dampening).

Speed Desired BW

[Speed Desired BW] sets the speed loop bandwidth and determines the dynamic behavior of the speed loop. As bandwidth increases, the speed loop becomes more responsive and can track a faster changing speed reference. Adjusting this parameter will cause the drive to calculate and change [Ki Speed Loop] and [Kp Speed Loop] gains. Setting this parameter equal to zero allows manual adjustments to Ki and Kp.

Total Inertia

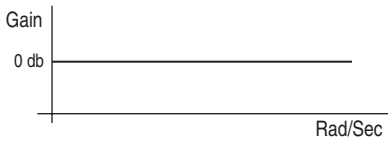
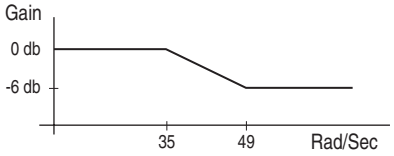
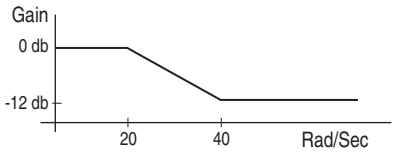
[Total Inertia] represents the time in seconds, for a motor coupled to a load to accelerate from zero to base speed, at rated motor torque. The drive calculates Total Inertia during the autotune inertia procedure. Adjusting this parameter will cause the drive to calculate and change [Ki Speed Loop] and [Kp Speed Loop] gains.

Simulator

The simulator mode allows the drive to be operated in a closed loop simulation mode without a motor connected and is meant for demo purposes only. If a motor is connected with this mode selected, very erratic and unpredictable operation will occur.

Speed Feedback Filter *700VC ONLY*

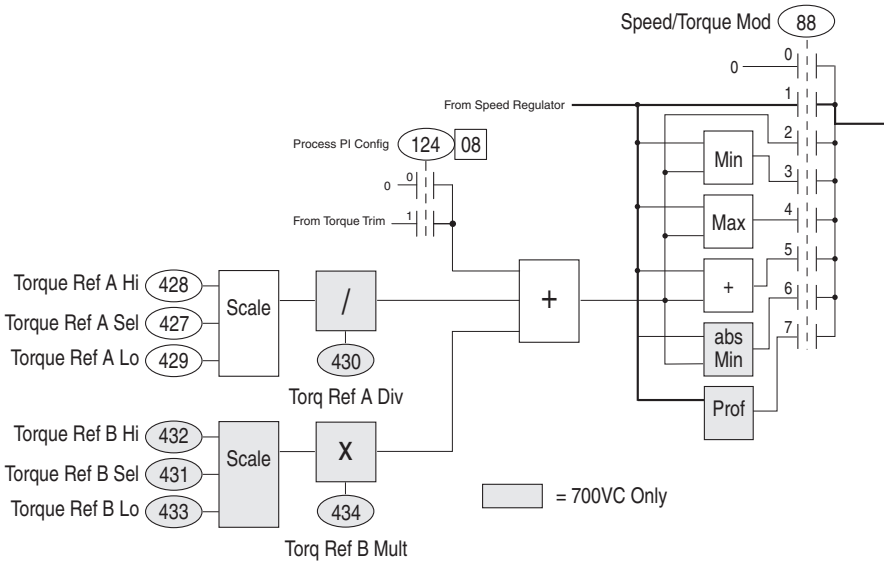
[Fdbk Filter Select] determines the type of filter to use for the speed feedback. The filter is used to filter out high frequency signals (noise) by reducing the gain at high frequencies. The selections for the filter are:

Description	To select this type of filter . . .	Select this value . . .
No filter		0
A light 35/49 radian feedback filter		1
A heavy 20/40 radian feedback filter		2

Speed/Torque Mode

70EC ✓ 700VC ✓

The drive can be programmed to operate as a velocity regulator, a torque regulator, or a combination of the two as follows.



[Speed/Torque Mod], parameter 88 is used to select the mode of operation. Zero torque current is allowed when set to “0.” When set to a “1,” the drive/motor is operated in speed mode. The torque command changes as needed to maintain the desired speed. A value of “2” selects torque mode. In torque regulation mode, the drive controls the desired motor torque. The motor speed will be a result of the torque command and load present at the motor shaft. Min and Max mode are selected by values 3 and 4, respectively. These two modes offer a combination of speed and torque operation. The algebraic minimum or maximum of speed/torque will be the operating point. The drive will automatically switch from speed to torque mode (or from torque to speed) based on the dynamics of the motor/load.

The Min mode is typically used with positive torque and forward speed operation, the minimum of the two being closest to zero. The Max mode is opposite, typically used with reverse speed and negative torque, the maximum being the least negative (closest to zero). Sum mode is selected when set to “5.” This mode allows an external torque command to be added to the speed regulator output.

Zero Torque Mode

Operation in zero torque mode allows the motor to be fully fluxed and ready to rotate when a speed command or torque command is given. For a cyclical application where through put is a high priority this mode can be used. The control logic can select zero torque during the “rest” portion of a machine cycle instead of stopping the drive. When the cycle start occurs, instead of issuing a start to the drive, a speed regulate mode can be selected. The drive will then immediately accelerate the motor without the need for “flux up” time.

Important: Zero Torque may excessively heat the motor if operated in this mode for extended periods of time. Flux current is still present when the drive is operating in zero torque mode. A motor with an extended speed range or separate cooling methods (blower) may be required.

Speed Regulation Mode

Operating as a speed regulator is the most common and therefore simplest mode to setup. Examples of speed regulated applications are blowers, conveyors, feeders, pumps, saws, and tools. In a speed regulated application, the torque reference is generated by the speed regulator output. Note that under steady state conditions the speed feedback is steady while the torque reference is a constantly adjusting signal. This is required to maintain the desired speed. At transient state, the torque reference will change dramatically to compensate for a speed change. A short duration change in speed is the result of increasing or decreasing the load very rapidly.

Torque Regulation Mode

A torque regulated application can be described as any process that requires some tension control. An example of this is a winder or unwind where material is being “drawn” or pulled with a specific tension required. The process requires another element setting the speed. Configuring the drive for torque regulation requires [Speed/Torque Mod] to be set to “2.” In addition, a torque reference signal must be selected through [Torque Ref A] or [Torque Ref B]. When operating in torque mode, the motor current will be adjusted to achieve the desired torque. If the material being wound/unwound breaks, the load will decrease dramatically and the motor can potentially go into a “runaway” condition.

Torque Reference

[Torque Ref A Hi] and [Torque Ref A Lo], parameters 428 & 429 are used to scale Torque Ref A only when [Torque Ref A Sel], parameter 427 is set to an analog output. Torque Ref A is divided by [Torq Ref A Div], parameter 430 (PF700VC only) regardless of the source of Torque Ref A.

[Torque Ref B Hi] and [Torque Ref B Lo], Parameter 432 & 433 are used to scale Torque Ref B only when [Torque Ref B Sel], parameter 431 is set to an analog output. Torque Ref B is multiplied by [Torq Ref B Mult] regardless of the source of Torque Ref A. Note: Only the PF700VC has a second torque reference (“Torque Ref B”).

When the Process PID loop is setup for torque trim ([Process PI Config], bit 8 “Torque Trim” is set to 1), the output of the Process PI Loop also becomes a torque reference.

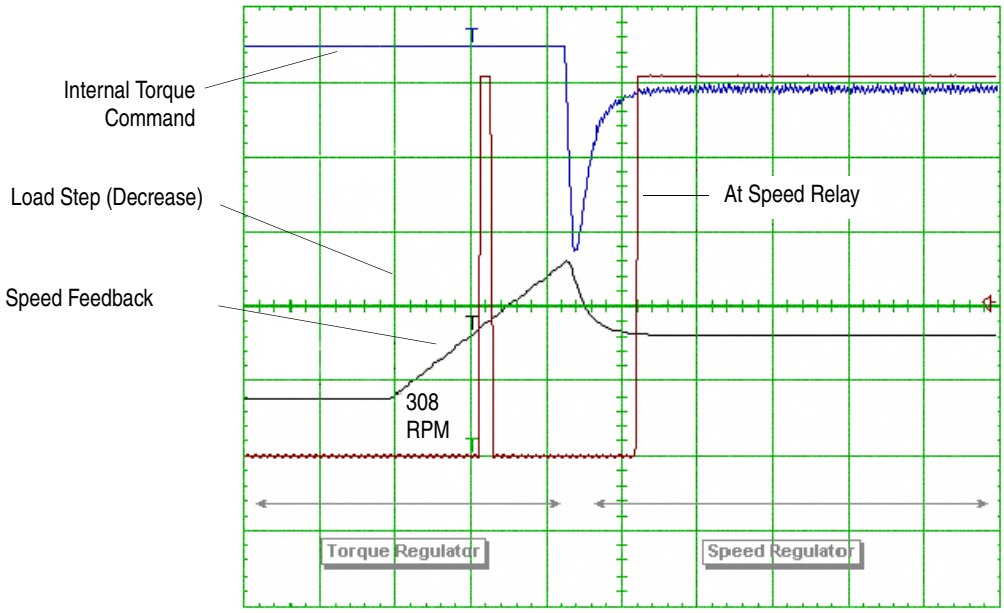
The final torque reference, in the Torque Mode, is the sum of scaled Torque Ref A, scaled Torque Ref B (700VC only) and the output of the Process PID loop when it is set to trim torque.

Min Torq/Spd and Max Torq/Spd Modes

These modes compare the speed and torque commands. The smallest (min mode) or largest (max mode) of these two values is used. These modes can be thought of as a Speed Limited Adjustable Torque operation. Instead of operating the drive as a pure torque regulator, the “runaway” condition can be avoided by limiting the speed to whatever speed reference the drive is programmed for. A winder is a good example for the application of the Min Torq/Spd operating mode. Max mode would be used if both speed and torque are negative, in which case the largest (smallest negative value) is the result.

Figure 20 illustrates how min mode operates. The drive begins operating as a torque regulator. The torque reference causes the motor to operate at 308 RPM. The speed reference is 468 RPM, so the minimum is to operate as a torque regulator. While operating in torque regulation, the load decreases and the motor speeds up. Notice that the torque command has not changed. When the speed regulator comes out of saturation, it clamps the speed and now the drive operates as a speed regulator.

Figure 20 Min Mode Operation



Sum Mode

This mode allows an external torque input to be summed with the torque command generated by the speed regulator, and can be used for applications that have precise speed changes with critical time constraints. If the torque requirement and timing are known for a given speed change, then the external torque input can be used to preload the integrator. The timing of the speed change and the application of an external torque command change must be coordinated for this mode to be useful. The sum mode will then work as a feed forward to the torque regulator.

Absolute Min Mode *700VC ONLY*

This mode regulates to the smallest absolute value of torque or speed, when the torque reference and torque generated from the speed regulator are compared.

Position/Speed Profile Mode *700VC ONLY*

The drive operates as a speed or position regulator as determined by the Profile Step parameters (720-877) and Setup parameters (705-719). See "Position Indexer/ Speed Profiler" on page 61 for complete description of this function.

Start Permissives

Start permissives are conditions required to permit the drive to start in any mode – run, jog, auto-tune, etc. When all permissive conditions are met the drive is considered *read*y to start. The ready condition is available as the *drive ready* status.

Permissive Conditions

1. No faults can be active.
2. No type2 alarms can be active.
3. The TB Enable input (if configured) must be closed.
4. The DC bus precharge logic must indicate it is a start permissive.
5. All Stop inputs must be negated (See special Digital Inputs Stops Configuration issues below).
6. No configuration changes (parameters being modified) can be in-progress.

If all permissive conditions are met, a valid start, run or jog command will start the drive. The status of all inhibit conditions, except for item 6 above, are reflected in [Start Inhibits].

Stop Modes

Several methods are available for braking or stopping a load as described in the table below.

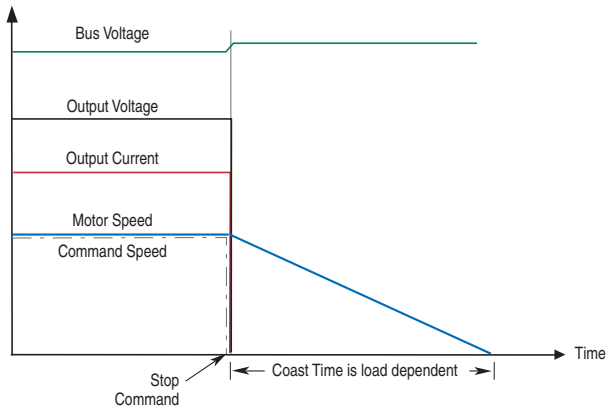
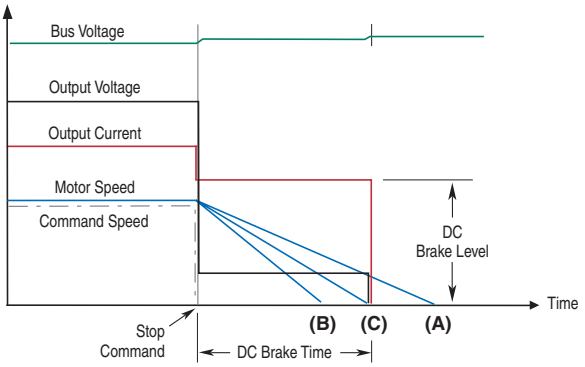
Method	Use When Application Requires . . .	Braking Power
Ramp	• The fastest stopping time or fastest ramp time for speed changes (external brake resistor or regenerative capability required for ramp times faster than the methods below). • High duty cycles, frequent stops or speed changes. (The other methods may result in excessive motor heating).	Most, if an external resistor or regenerative device is connected.
Fast Brake	• Additional braking capability without use of an external brake resistor or regenerative unit, but only effective during stop events, not speed changes. **Important:** For this feature to function properly the active Bus Reg Mode A or B must be set to Adjust "Freq" and NOT be "Disabled".	More than Flux Braking or DC Brake
Flux Braking	• Fast speed changes and fast stopping time. • Typical stop from speeds below 50% of base speed ("Flux Braking" will likely stop the load faster than "Fast Brake" in this case). **Important:** This can be used in conjunction with "Ramp" or "Ramp to Hold" for additional braking power or with "Fast Brake" or "DC Brake" for speed changes. **Important:** For this feature to function properly the active Bus Reg Mode A or B must be set to Adjust "Freq" and NOT be "Disabled".	More than DC Brake
DC Brake	• Additional braking capability without use of external brake resistor or regenerative units.	Less than above methods

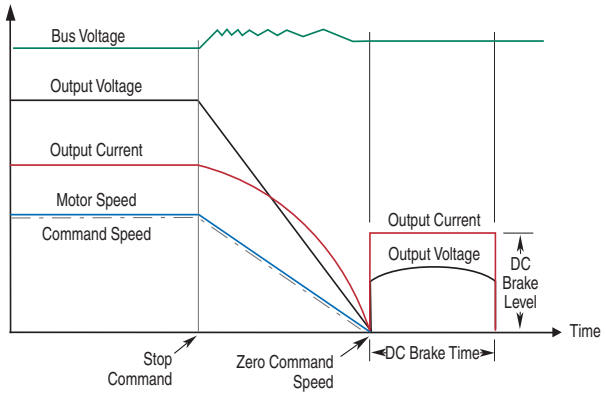
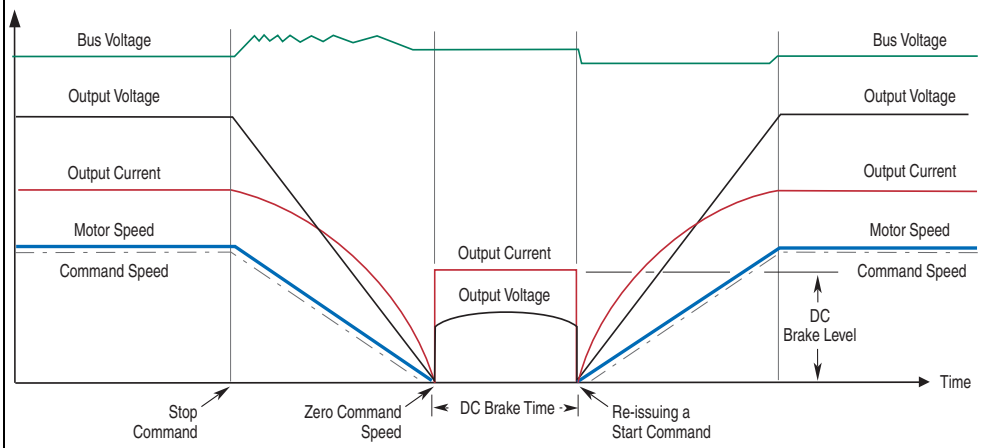
In addition to these modes, the drive can be programmed for "Coast" and "Ramp to Hold," which are described in further detail in this section.

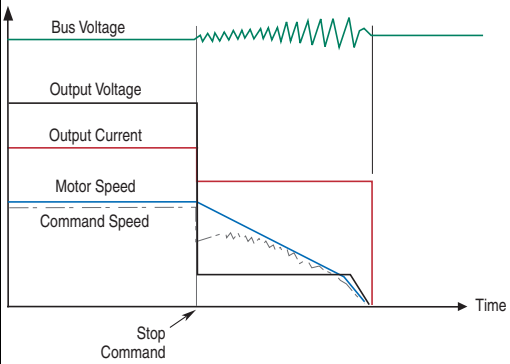
Configuration

- [Stop/Brk Mode A], parameter 155
- [Stop/Brk Mode B], parameter 156
  - 0 = Coast
  - 1 = Ramp
  - 2 = Ramp to Hold
  - 3 = DC Brake
  - 4 = Fast Brake (PowerFlex 70 & 700 Only)
- [DC Brk Lvl Sel], parameter 157
  - 0 = "DC Brake Lvl" – selects parameter 158 as the source for the DC brake level
  - 1 = "Analog in 1"
  - 2 = "Analog in 2"
- [DC Brake Level], parameter 158 – sets the DC brake level in amps, when parameter 157 = "DC Brake Lvl"
- [DC Brake Time], parameter 159 – sets the amount of time that DC braking is applied after the ramp (if any).
- [Flux Braking], parameter 166
  - 0 = Disabled, 1 = Enabled
- [Digital InX Sel], parameters 361-366
  - 13 = "Stop Mode B" – setting a digital input to this function allows the use of a digital input to switch between Stop Mode A (open input) and Stop Mode B (closed input).

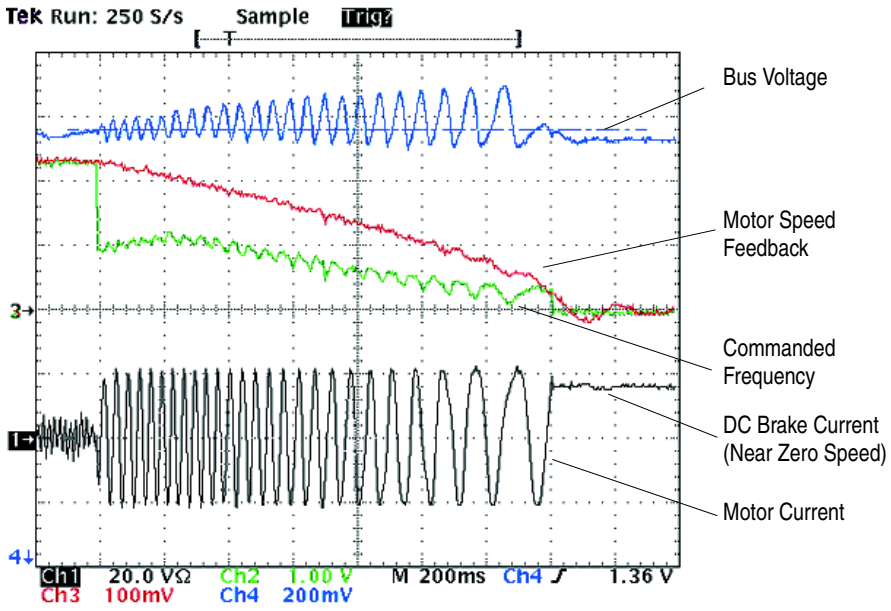
Detailed operation

Mode	Description
Coast to Stop	 **Coast** is selected by setting [Stop Mode A/B] to a value of "0." When in Coast to Stop, the drive acknowledges the Stop command by shutting off the drive output and releasing control of the motor. The load and motor will coast until the kinetic energy is dissipated.
DC Brake to Stop	 This method uses DC injection of the motor to Stop and/or hold the load. **DC Brake** is selected by setting [Stop Mode A/B] to a value of "3." The amount of time that braking will be applied is programmed in [DC Brake Time] and the magnitude of the current used for braking is programmed in and [DC Brake Level]. This mode of braking will generate up to 40% of rated motor torque for braking and is typically used for low inertia loads with infrequent Stop cycles. 1. On Stop, 3 phase drive output goes to zero (off) 2. Drive outputs DC voltage on the last used phase at the level programmed in [DC Brake Level], parameter 158. This voltage causes a "stopping" brake torque. If the voltage is applied for a time that is longer than the actual possible stopping time, the remaining time will be used to attempt to hold the motor at zero speed (decel profile "B" on the diagram above). 3. DC voltage to the motor continues for the amount of time programmed in [DC Brake Time], parameter 159. Braking ceases after this time expires. 4. After the DC Braking ceases, no further power is supplied to the motor. The motor/load may or may not be stopped. The drive has released control of the motor/load (decel profile "A" on the diagram above). 5. The motor, if rotating, will coast from its present speed for a time that is dependent on the remaining kinetic energy and the mechanics of the system (inertia, friction, etc.). 6. Excess motor current and/or applied duration, could cause motor damage. The user is also cautioned that motor voltage can exist long after the Stop command is issued. The right combination of Brake Level and Brake Time must be determined to provide the safest, most efficient stop (decel profile "C" on the diagram above).

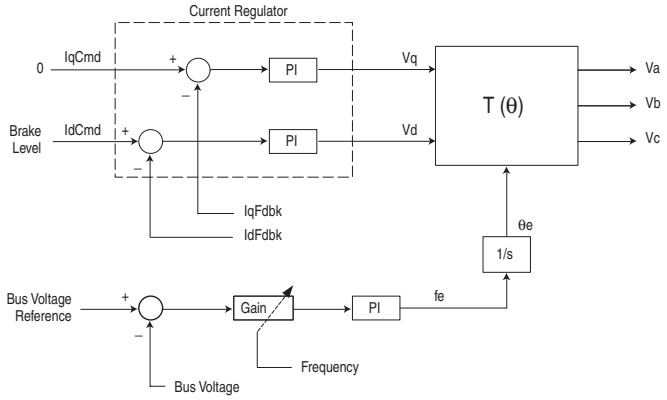
Mode	Description
Ramp	 This method uses drive output reduction to stop the load. **Ramp** is selected by setting [Stop Mode A/B] to a value of "1". The drive will ramp the frequency to zero based on the deceleration time programmed into [Decel Time 1/2]. The "normal" mode of machine operation can utilize [Decel Time 1]. If the machine "stop" requires a faster deceleration than desired for normal deceleration, [Decel Time 2] can be activated with a faster rate selected. When in Ramp mode, the drive acknowledges the stop command by decreasing or "ramping" the output voltage and frequency to zero in a programmed period (Decel Time), maintaining control of the motor until the drive output reaches zero. The drive output is then shut off. The load and motor should follow the decel ramp. Other factors such as bus regulation and current limit can alter the actual decal rate. Ramp mode can also include a "timed" hold brake. Once the drive has reached zero output hertz on a Ramp-to-Stop and both parameters [DC Brake Time] and [DC Brake Level] are not zero, the drive applies DC to the motor producing current at the DC Brake Level for the DC Brake Time. 1. On Stop, drive output will decrease according to the programmed pattern from its present value to zero. The pattern may be linear or squared. The output will decrease to zero at the rate determined by the programmed [Maximum Freq] and the programmed active [Decel Time x]. 2. The reduction in output can be limited by other drive factors such as bus or current regulation. 3. When the output reaches zero the output is shut off. 4. The motor, if rotating, will coast from its present speed for a time that is dependent on the mechanics of the system (inertia, friction, etc.).
Ramp to Hold	 This method combines two of the methods above. It uses drive output reduction to stop the load and DC injection to hold the load at zero speed once it has stopped. 1. On Stop, drive output will decrease according to the programmed pattern from its present value to zero. The pattern may be linear or squared. The output will decrease to zero at the rate determined by the programmed [Maximum Freq] and the programmed active [Decel Time x]. 2. The reduction in output can be limited by other drive factors such as bus or current regulation. 3. When the output reaches zero, 3 phase drive output goes to zero (off) and the drive outputs DC voltage on the last used phase at the level programmed in [DC Brake Level], parameter 158. This voltage causes a "holding" brake torque. 4. DC voltage to the motor continues until a Start command is reissued or the drive is disabled. 5. If a Start command is reissued, DC Braking ceases and the drive returns to normal AC operation. If an Enable command is removed, the drive enters a "not ready" state until the enable is restored.

Mode	Description
Fast Brake	 This method takes advantage of the characteristic of the induction motor whereby frequencies greater than zero (DC braking) can be applied to a spinning motor that will provide more braking torque without causing the drive to regenerate. 1. On Stop, the drive output will decrease based on the motor speed, keeping the motor out of the regen region. This is accomplished by lowering the output frequency below the motor speed where regeneration will not occur. This causes excess energy to be lost in the motor. 2. The method uses a PI based bus regulator to regulate the bus voltage to a reference (e.g. 750V) by automatically decreasing output frequency at the proper rate. 3. When the frequency is decreased to a point where the motor no longer causes the bus voltage to increase, the frequency is forced to zero. DC brake will be used to complete the stop if the DC Braking Time is non-zero, then the output is shut off. 4. Use of the current regulator ensures that over current trips don't occur and allow for an easily adjustable and controllable level of braking torque. 5. Use of the bus voltage regulator results in a smooth, continuous control of the frequency and forces the maximum allowable braking torque to be utilized at all times. 6. **Important:** For this feature to function properly the active Bus Reg Mode A or B must be set to Adjust "Freq" and NOT be "Disabled".

Test Example for Fast Braking


Tek Run: 250 S/s Sample Trig?
Bus Voltage
Motor Speed Feedback
Commanded Frequency
DC Brake Current (Near Zero Speed)
Motor Current
Ch1 20.0 VΩ Ch2 1.00 V M 200ms Ch4 1.36 V
Ch3 100mV Ch4 200mV

Implementation Block Diagram for Fast Braking



User Display

The User Display is shown when module keys have been inactive for a predetermined amount of time. The display can be programmed to show pertinent information.

Setting the User Display

Step	Key(s)	Example Displays
1. Press the Up Arrow or Down Arrow to scroll to Operator Intrfc. Press Enter.		Operator Intrfc: Change Password **User Display** Parameters
2. Press the Up Arrow or Down Arrow to scroll to User Display. Press Enter.		
3. Select the desired user display. Press Enter. Scroll to the parameter that the user display will be based on.		
4. Press Enter. Set a scale factor.		
5. Press Enter to save the scale factor and move to the last line.		
6. Press the Up Arrow or Down Arrow to change the text.		
7. Press Enter to save the new user display.		

Setting the Properties of the User Display

The following HIM parameters can be set as desired:

- User Display - Enables or disables the user display.
- User Display 1 - Selects which user display parameter appears on the top line of the user display.
- User Display 2 - Selects which user display parameter appears on the bottom line of the user display.
- User Display Time - Sets how many seconds will elapse after the last programming key is touched before the HIM displays the user display.

User Sets

Normal Mode

The drive has additional parameter storage memory beyond what is being used for operation at any given time. This additional memory is divided up into 3 areas called User Sets. When the drive is stopped, a HIM command or parameter command (similar to Reset to Defaults) can be used to load any of these user sets. These methods are acceptable for occasional use of the User Sets and can be accessed in the HIM “Memory Storage” menu area named “Device User Sets” or through [Load Frm Usr Set] and [Save To User Set], parameters 198 & 199.

Dynamic Mode

If frequent or automated control of the user sets is required by an application, Dynamic Mode is required not only to meet application requirements, but also to avoid non-volatile memory write cycle limitations. In this mode, either a parameter (typically controlled by the network) or digital inputs are used to quickly transfer complete User Sets to RAM without affecting any non-volatile memory.

- [Dyn UserSet Cnfg], parameter 204 enables or disables dynamic selection of user sets and controls whether digital inputs or the network activates the users sets:
  - Bit 0, “Dynamic Mode” 0 = disabled, 1 = enabled
  - Bit 1, “Ctrl Source” 0 = controlled from digital inputs, 1 = controlled from [Dyn User Set Sel], parameter 205.

- [Digital InX Sel], parameters 361-366 define the functions assigned to each digital input and are used with Dynamic Mode only when user sets will be controlled from digital inputs (parameter 204 = xxxx xxxx xxxx xx01) rather than over the network.
  - 41, “UserSet Sel1” = the least significant bit of the binary combination that activates a specific user set.
  - 42, “UserSet Sel2” = the most significant bit of the binary combination that activates a specific user set.

  These digital input functions control the user sets as follows:

Digital Input Set to “42” (UserSet Sel2)	Digital Input Set to “41” (UserSet Sel1)	User Set
Open (0)	Open (0)	1
Open (0)	Closed (1)	2
Closed (1)	Open (0)	3
Closed (1)	Closed (1)	3

- [Dyn UserSet Sel], parameter 205 is used in Dynamic Mode when user sets will be controlled from a network (parameter 204 = xxxx xxxx xxxx xx11) instead of digital inputs:
  - Bit 0, “UserSet Sel1” 0 = active, 1 = not active. The least significant bit of the binary combination that activates a specific user set.
  - Bit 1, “UserSet Sel2” 0 = active, 1 = not active. The most significant bit of the binary combination that activates a specific user set

These parameter bits are normally written to over a network (using Datalinks) and control the user sets as follows:

[Dyn UserSet Sel] Parameter 205, bit 1	[Dyn UserSet Sel] Parameter 205, bit 0	User Set
0	0	1
0	1	2
1	0	3
1	1	3

- [Dyn UserSet Actv], parameter 206 reports the status of Dynamic Mode and which User Set is active. Bit Definitions follow:
  - Bit 0 = “Dynamic Mode” 0 = active, 1 = not active
  - Bit 1 = “User Set 1” 0 = active, 1 = not active
  - Bit 2 = “User Set 2” 0 = active, 1 = not active
  - Bit 3 = “User Set 3” 0 = active, 1 = not active

User Set Rules

- In Dynamic Mode, all three user sets must have parameter settings, even if only two of the user sets will be utilized.
- The desired settings for [Dyn UserSet Cnfg] must be saved as part of all three user sets.
- Switching between user sets occurs in less than 50 milliseconds, but must be done while the drive is stopped.
- Digital input settings in all three user sets must be equal for dynamic mode to operate, even if the network control (instead of digital input control) is used to switch between user sets.

Voltage Class

PowerFlex drives are sometimes referred to by voltage “class,” which identifies the general input voltage to the drive. Voltage class includes a range of voltages. For example, a 400V class drive will have an input voltage range of 380-480V AC. While the hardware remains the same for each class, other variables, such as factory defaults, catalog number and power unit ratings will change. In most cases, all drives within a voltage class can be reprogrammed to another drive in the class by resetting the defaults to something other than “factory” settings. Refer to "Reset Parameters" on page 88 for an explanation of parameter reset options that are voltage class specific.

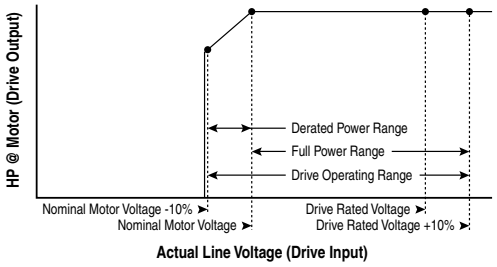
[Voltage Class], parameter 202 is required by the drive when parameter downloads occur and is generally not programmed individually. [Voltage Class] provides a “Low Voltage” and “High Voltage” setting. The default value is dependent on the voltage that matches the catalog number (e.g. 400V or 480V). For example, a drive shipped as 400V (catalog code “C”) will have a default of “Low Voltage” for [Voltage Class]. A drive shipped as 480V (catalog code “D”) will have a default of “High Voltage.” When a change is made to [Voltage Class], the continuous current rating of the drive will change by an amount equal to the published difference between catalog numbers.

Voltage Tolerance

70EC 700VC

Drive Rating	Nominal Line Voltage	Nominal Motor Voltage	Drive Full Power Range	Drive Operating Range
200-240	200	200*	200-264	180-264
	208	208	208-264	
	240	230	230-264	
380-480	380	380*	380-528	342-528
	400	400	400-528	
	480	460	460-528	
500-600	600	575*	575-660	432-660
	600	575*	575-660	475-759
	690	690	690-759	475-759

Drive Full Power Range =	Nominal Motor Voltage to Drive Rated Voltage +10%. Rated power is available across the entire Drive Full Power Range.
Drive Operating Range =	Lowest (*) Nominal Motor Voltage –10% to Drive Rated Voltage +10%. Drive Output is linearly derated when Actual Line Voltage is less than the Nominal Motor Voltage.

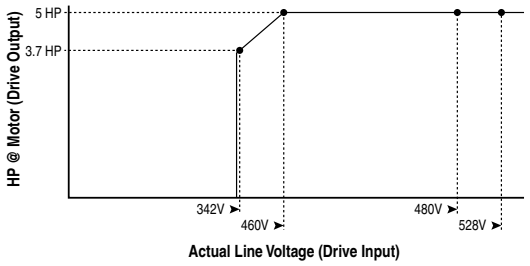


Example:

Calculate the maximum power of a 5 HP, 460V motor connected to a 480V rated drive supplied with 342V Actual Line Voltage input.

- Actual Line Voltage / Nominal Motor Voltage = 74.3%
- 74.3% × 5 HP = 3.7 HP
- 74.3% × 60 Hz = 44.6 Hz

At 342V Actual Line Voltage, the maximum power the 5 HP, 460V motor can produce is 3.7 HP at 44.6 Hz.



Supplemental Information

Engineering Parameters

ATTENTION: To guard against unstable or unpredictable operation, the following parameters must only be changed by qualified service personnel.

The following parameters can only be viewed when "2, Reserved" is selected in parameter 196, [Param Access Lvl].

File	Group	No.	Parameter Name & Description	Values	PF 70	PF 700	PF700H
UTILITY	Diag-Motor Cntl	500	**[KI Current Limit]** Current Limit Integral gain. This gain is applied to the current limit error signal to eliminate steady state current limit error. A larger value increases overshoot during a step of motor current/load.	Default: 1500 Min/Max: 0/10000 Units: 1	✔	✔	
		501	**[KD Current Limit]** Current Limit Derivative gain. This gain is applied to the sensed motor current to anticipate a current limit condition. A larger value reduces overshoot of the current relative to the current limit value.	Default: 500 Min/Max: 0/10000 Units: 1	✔	✔	
		502	**[Bus Reg ACR Kp]** This proportional gain, in conjunction with parameter 60, adjusts the output frequency of the drive during a bus limit or inertia ride through condition. The output frequency is adjusted in response to an error in the active, or torque producing, current to maintain the active bus limit, or inertia ride through bus reference. A larger value of gain reduces the dynamic error of the active current.	Default: 450 Min/Max: 0/10000 Units: 1	✔	✔	
		503	**[Jerk]** Allows you to adjust the amount of S-Curve, or "Jerk" applied to the Acc/Dec rate. To enable the Jerk feature, bit 1 of parameter 56 must be set high.	Default: 900 Min/Max: 2/30000 Units: 1	✔	✔	
		504	**[Kp LL Bus Reg]** This proportional gain adjusts the active current command during an inertia-ride through condition, in response to a bus error. A larger value of gain reduces the dynamic error of the bus voltage as compared to the bus voltage reference.	Default: 500 Min/Max: 0/10000 Units: 1	✔	✔	
		505	**[Kd LL Bus Reg]** Line Loss Bus Reg Kd is a derivative gain, which is applied to the sensed bus voltage to anticipate dynamic changes and minimize them. A larger value reduces overshoot of the bus voltage relative to the inertia-ride through bus voltage reference.	Default: 500 Min/Max: 0/10000 Units: 1	✔	✔	
		506	**[Angl Stblty Gain]** Angle Stability Gain adjusts the electrical angle to maintain stable motor operation. An increase in the value increases the angle adjustment.	Default: 51 Min/Max: 0/32767 Units: 1	✔	✔	
		507	**[Volt Stblty Gain]** Adjusts the output voltage to maintain stable motor operation. An increase in the value increases the output voltage adjustment.	Default: 93 Min/Max: 0/32767 Units: 1	✔	✔	

File	Group	No.	Parameter Name & Description	Values	PF 70	PF 700	PF700H
UTILITY	Diag-Motor Cntl	508	**[Stability Filter]** The Stability Filter coefficient is used to adjust the bandwidth of a low pass filter. The smaller the value of this coefficient, the lower the bandwidth of the filter.	Default: 3250 Min/Max: 0/32767 Units: 1	✔	✔	
		509	**[Lo Freq Reg Kpld]** This proportional gain adjusts the output voltage at very low frequency in response to the reactive, or d-axis, motor current. A larger value increases the output voltage change.	Default: 64 Min/Max: 0/32767 Units: 1	✔	✔	
		510	**[Lo Freq Reg Kplq]** The proportional gain adjusts the output voltage at very low frequency in response to the active, or q-axis, motor current. A larger value increases the output voltage change.	Default: 64 Min/Max: 0/32767 Units: 1	✔	✔	
		511	**[Ki Cur Reg]** This integral gain adjusts the output voltage in response to the q and d axis motor currents. A larger value increases the output voltage change.	Default: 44 Min/Max: 0/32767 Units: 1	✔	✔	
		512	**[Kp Cur Reg]** This proportional gain adjusts the output voltage in response to the q and d axis motor currents. A larger value increases the output voltage change.	Default: 1600 Min/Max: 0/32767 Units: 1	✔	✔	
	Diag-DACs	523	**[Bus Utilization]** This value sets the drive output voltage limit as a percentage of the fundamental output voltage when operating in 6 step mode. Values above 95% increase harmonic content and jeopardize control stability. This output voltage limit is strictly a function of input line and resulting bus voltage.	Default: 95.0% Min/Max: 85.0/100.0% Units: 0.1%	✔	✔	
		524	**[PWM Type Sel]** Allows selection of the active PWM type. A value of 0 is default, and results in a change of PWM method at approximately 2/3 of rated motor frequency. If this is unacceptable for harmonic or audible reasons, a value of 1 disables the change.	Default: 0 Min/Max: 0/1 Units: 1	✔	✔	
	Diag-Vector Cntl	525	**[Torq Adapt Speed]** Selects the operating frequency/speed at which the adaptive torque control regulators become active as a percent of motor nameplate frequency.	Default: 10.0% Min/Max: 0.0/100.0% Units: 0.1%	✔	✔	
		526	**[Torq Reg Enable]** Enables or disables the torque regulator.	Default: 1 Min/Max: 0/1 Units: 1	✔	✔	
		527	**[Kp Torq Reg]** Proportional gain for the torque regulator.	Default: 32 Min/Max: 0/32767 Units: 1	✔	✔	
		528	**[Ki Torq Reg]** Integral gain for the torque regulator.	Default: 128 Min/Max: 0/32767 Units: 1	✔	✔	
		529	**[Torq Reg Trim]** Torque Regulator trim gain. A larger value increases the developed torque. Typically used to compensate for losses between developed and shaft torque.	Default: 1.0 Min/Max: 0.5/1.5 Units: 0.1	✔	✔	
		530	**[Slip Reg Enable]** Enables or disables the slip frequency regulator.	Default: 1 Min/Max: 0/1 Units: 1	✔	✔	
		531	**[Kp Slip Reg]** Proportional gain for the slip frequency regulator.	Default: 256 Min/Max: 0/32767 Units: 1	✔	✔	

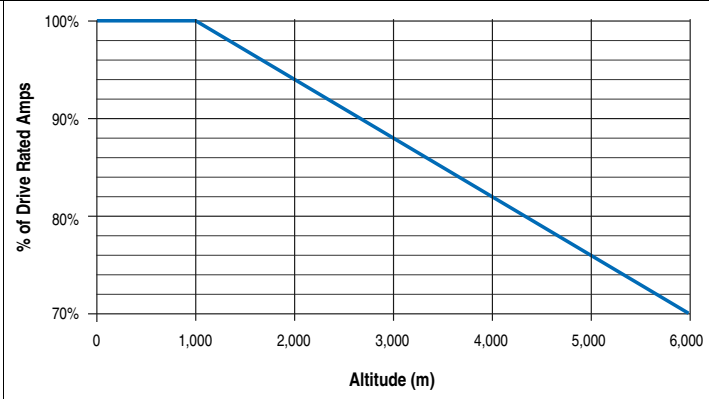
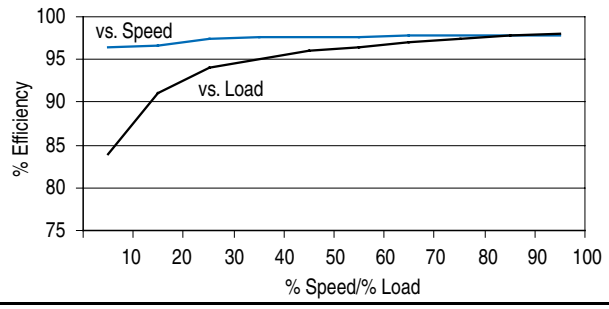
File	Group	No.	Parameter Name & Description	Values	PF 70	PF 700	PF700H
UTILITY	Diag-Vector Cntl	532	**[Ki Slip Reg]** Integral gain for the slip frequency regulator.	Default: 64 Min/Max: 0/32767 Units: 1	✔	✔	
		533	**[Flux Reg Enable]** Enables or disables the flux regulator.	Default: 1 Min/Max: 0/1 Units: 1	✔	✔	
		534	**[Kp Flux Reg]** Proportional gain for the flux regulator.	Default: 64 Min/Max: 0/32767 Units: 1	✔	✔	
		535	**[Ki Flux Reg]** Integral gain for the flux regulator.	Default: 32 Min/Max: 0/32767 Units: 1	✔	✔	
		536	**[Ki Flux Braking]** Proportional gain for the Flux Regulator.	Default: 100 Min/Max: 0/32767 Units: 1	✔	✔	
		537	**[Kp Flux Braking]** Integral gain for the Flux Regulator.	Default: 500 Min/Max: 0/32767 Units: 1	✔	✔	
		538	**[Rec Delay Time]** The delay that is enforced after a stop event prior to a flying start event. A setting of 1000 = 0.5 seconds.	Default: 1000 Min/Max: 1/30000 Units: 1	✔	✔	
		539	**Freq Reg Kp** Proportional gain for frequency portion of torque regulator in FVC encoderless mode.	Default: 450 Min/Max: 0/32767 Units: N/A	✔	✔	
		540	**Freq Reg Ki** Integral gain for frequency portion of torque regulator in FVC encoderless mode.	Default: 2000 Min/Max: 0/32767 Units: N/A	✔	✔	
		541	**Encdlss Ang Comp** Voltage vector angle compensation for long motor cables and switching characteristics in FVC encoderless mode. 1024 = 1 revolution.	Default: 0 Min/Max: -1023/+1023 Units: N/A	✔	✔	
		542	**Encdlss Vlt Comp** Voltage compensation for long motor cables and switching characteristics in FVC encoderless mode.	Default: 12.8 Min/Max: 0/Rated Volts x 0.5 Units: VAC	✔	✔	
		543	**Excitation Ki** Integral gain for current regulator during excitation phase of flying start.	Default: 44 Min/Max: 0/32767 Units: N/A	✔	✔	
		544	**Excitation Kp** Proportional gain for current regulator during excitation phase of flying start.	Default: 1800 Min/Max: 0/32767 Units: N/A	✔	✔	
		545	**In Phase Loss Lvl** Sensitivity of input phase loss detection. 325 = 8.1V DC bus ripple. (ripple volts/AC input VAC)^2 x 2^{20} = setting.	Default: 325 Min/Max: 10/1000 Units: N/A	✔	✔	
		546	**Out Phase Loss Lvl** Sensitivity of output phase loss detection.200 is approximately 5% drive rated current.	Default: 200 Min/Max: 1/400 Units: N/A		✔	
		547	**Ki Fast Braking** Integral gain for Fast Braking mode.	Default: 1000 Min/Max: 0/32767 Units: N/A	✔	✔	
		548	**Kp Fast Braking** Proportional gain for Fast Braking mode.	Default: 2000 Min/Max: 0/32767 Units: N/A	✔	✔	

File	Group	No.	Parameter Name & Description	Values	PF 70	PF 700	PF700H
UTILITY	Diag-Vector Cntl	549	**Flux Braking %** (% of normal output voltage) Gain adjustment for Flux Braking mode.	Default: 175 Min/Max: 100/250 Units: %	✔	✔	
		550	**Ki Flying Start** Integral gaing for Flying Start mode.	Default: 150 Min/Max: 20/5000 Units:		✔	
		551	**Ki DC Brake** Integral gain for DC Braking mode.	Default: 25 Min/Max: 0/500 Units:		✔	
		552	**Dead Time Comp** Voltage compensation for off time between PWM switching events.	Default: 75 Min/Max: 50/100 Units: %	✔		

Derating Guidelines

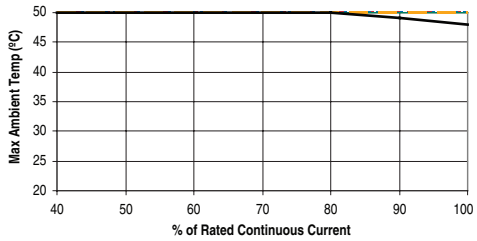
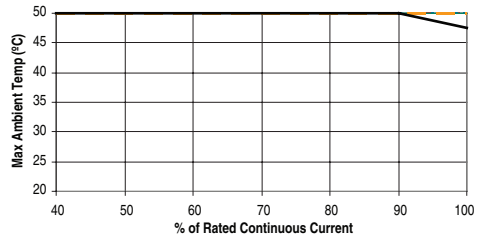
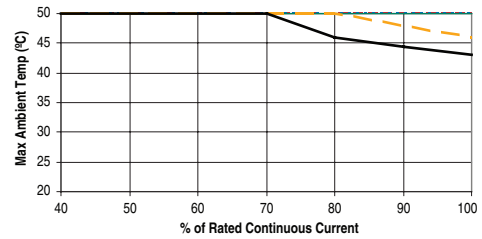
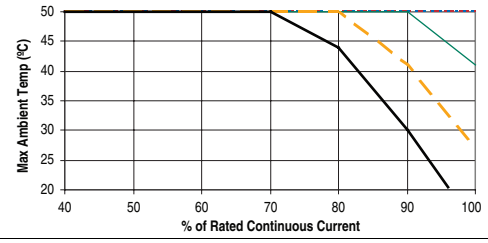
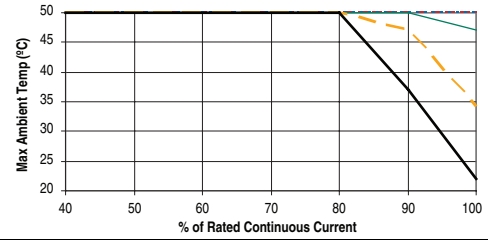
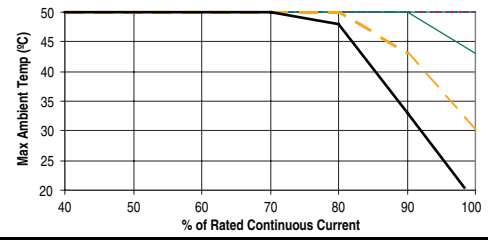
70EC ✔ 700VC ✔

PowerFlex 70 & 700 Altitude and Efficiency

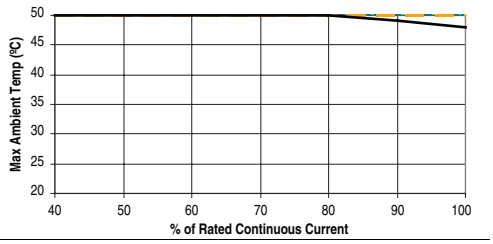
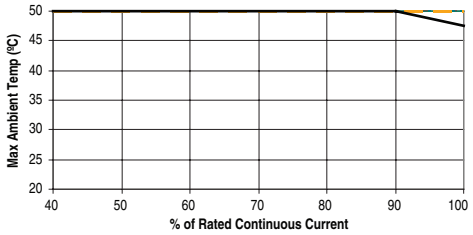
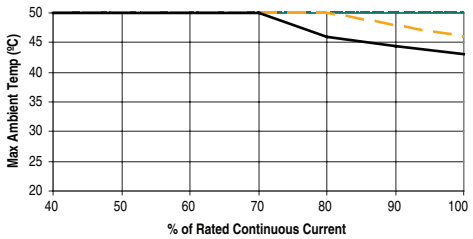
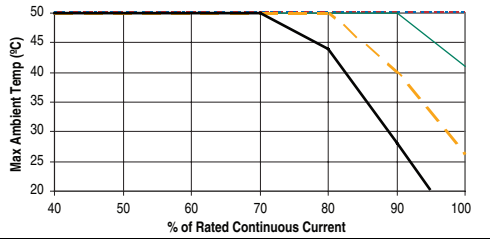
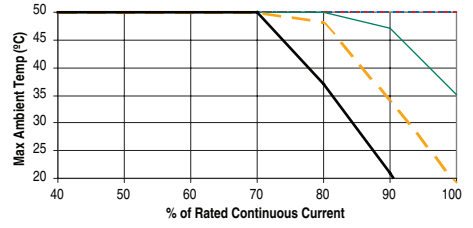
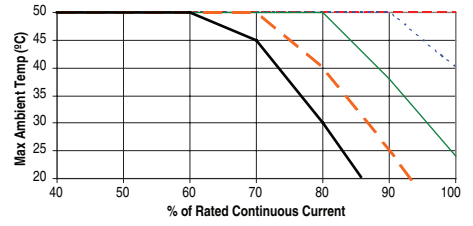
Frame	Type	Derate
All	Altitude	
	Efficiency (typical)	

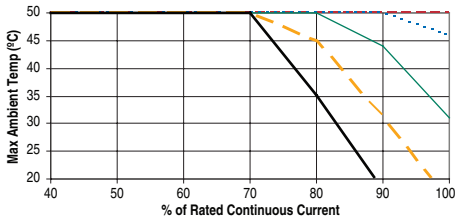
PowerFlex 70 Ambient Temperature/Load

240V AC

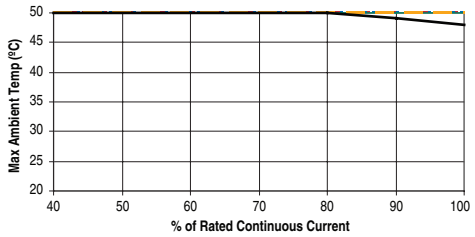
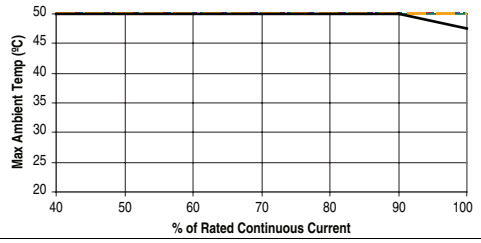
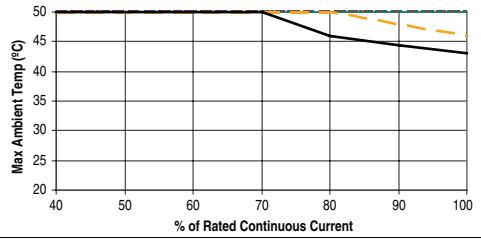
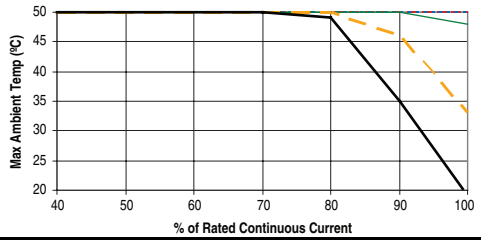
PowerFlex 70 Power Rating		Derating
ND HP	HD HP	2 kHz 4 kHz 6 kHz 8 kHz 10 kHz
240 Volt		
0.5 - 3.0	0.33 - 2.0	None
5.0	3.0	
7.5	5.0	
10	7.5	
15	10	
20	15	
25	20	

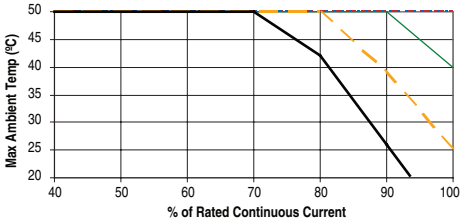
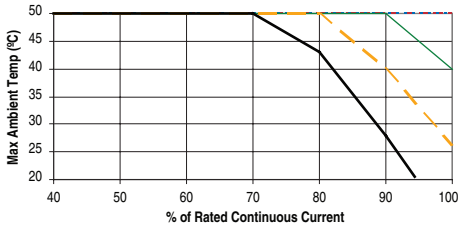
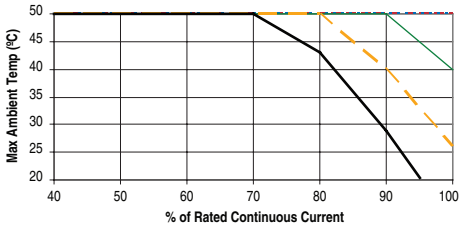
400V AC

PowerFlex 70 Power Rating		Derating
ND kW	HD kW	2 kHz 4 kHz 6 kHz 8 kHz 10 kHz
400 Volt		
0.37 - 5.5	0.25 - 4.0	None
7.5	5.5	
11	7.5	
15	11	
18.5	15	
22	18.5	
30	22	

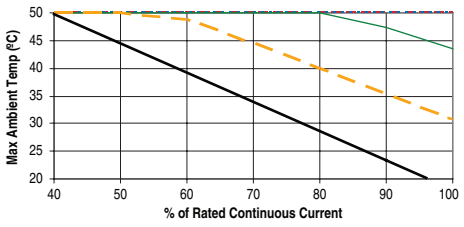
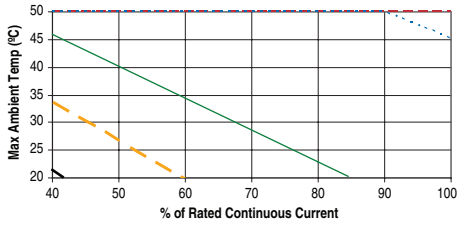
PowerFlex 70 Power Rating		Derating
ND kW	HD kW	2 kHz 4 kHz 6 kHz 8 kHz 10 kHz
400 Volt		
37	30	

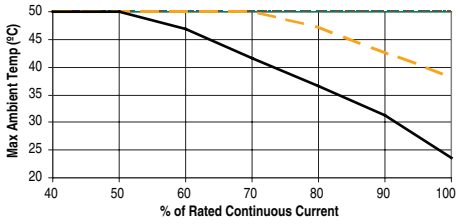
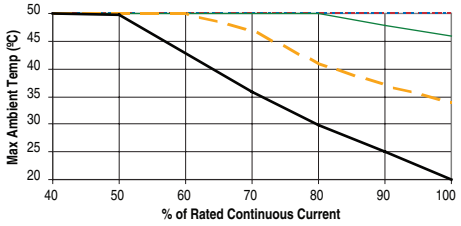
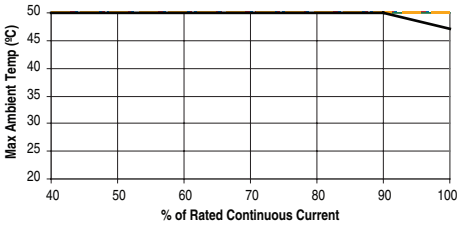
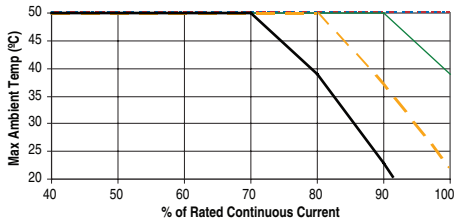
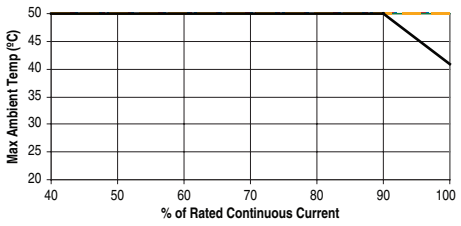
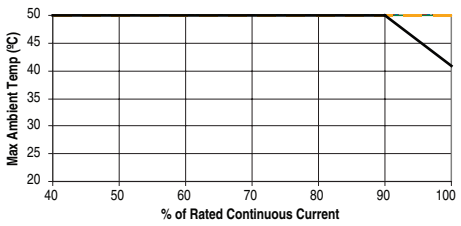
480V AC

PowerFlex 70 Power Rating		Derating
ND HP	HD HP	2 kHz 4 kHz 6 kHz 8 kHz 10 kHz
480 Volt		
0.5 - 7.5	0.33 - 5.0	None
10	7.5	
15	10	
20	15	
25	20	

PowerFlex 70 Power Rating		Derating
ND HP	HD HP	2 kHz 4 kHz 6 kHz 8 kHz 10 kHz
480 Volt		
30	25	
40	30	
50	40	

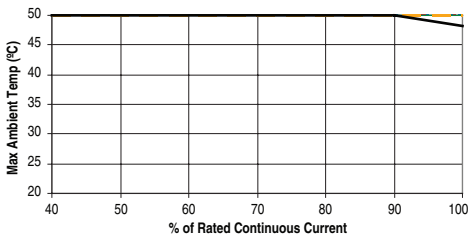
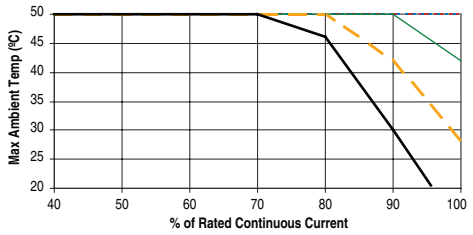
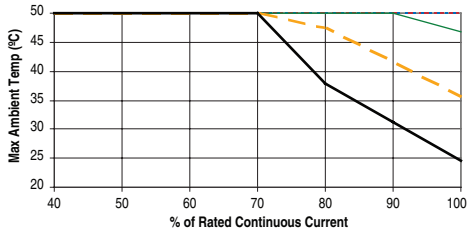
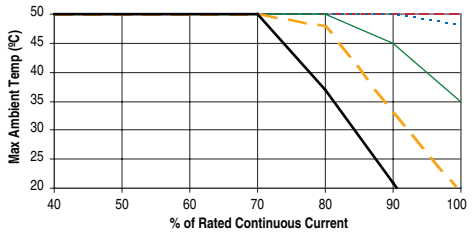
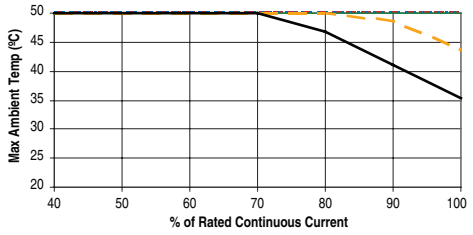
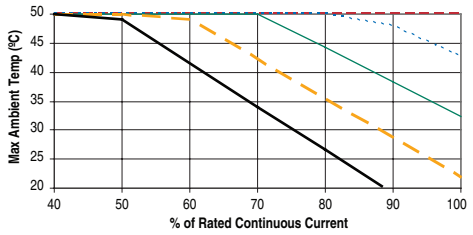
600V AC

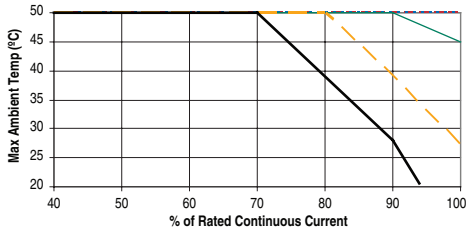
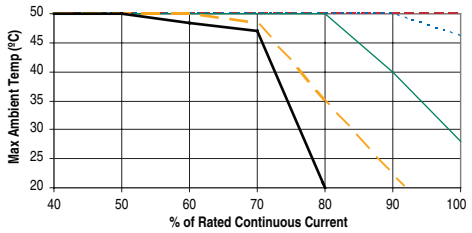
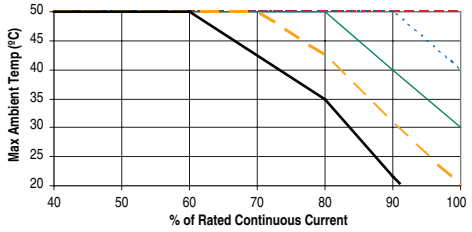
PowerFlex 70 Power Rating		Derating
ND HP	HD HP	2 kHz 4 kHz 6 kHz 8 kHz 10 kHz
600 Volt		
0.5 - 5.0	0.33 - 3.0	None
7.5	5.0	
10	7.5	

PowerFlex 70 Power Rating		Derating
ND HP	HD HP	2 kHz 4 kHz 6 kHz 8 kHz 10 kHz
600 Volt		
15	10	
20	15	
25	20	
30	25	
40	30	
50	40	

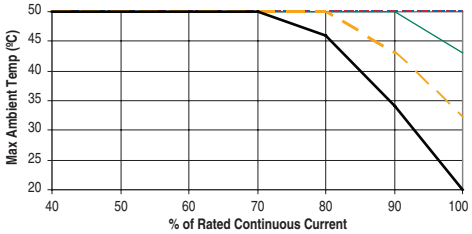
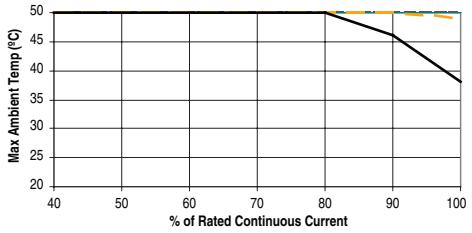
PowerFlex 700 Ambient Temperature/Load

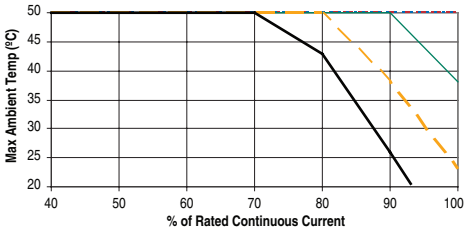
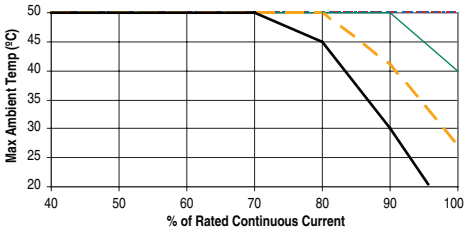
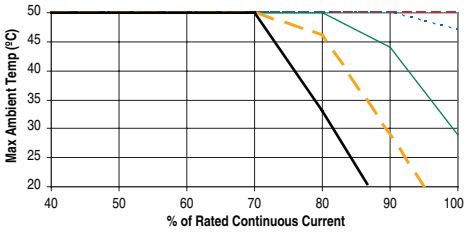
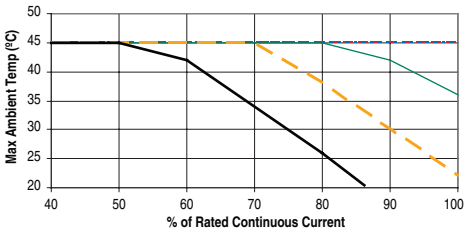
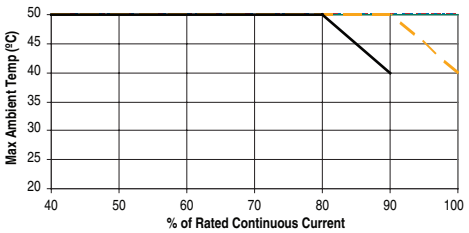
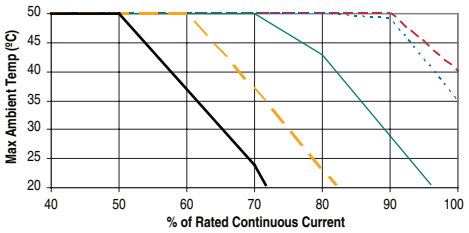
240V AC

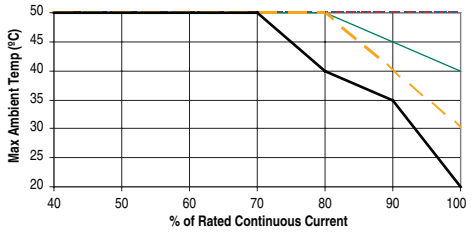
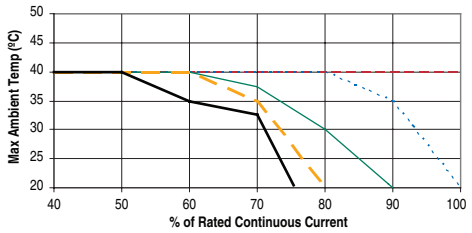
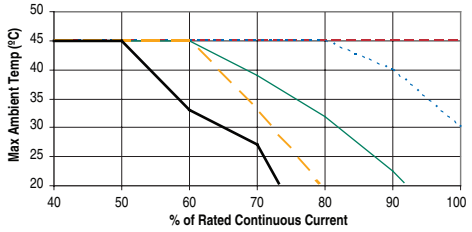
PowerFlex 700 Power Rating		Derating
ND HP	HD HP	2 kHz 4 kHz 6 kHz 8 kHz 10 kHz
240 Volt		
0.5 - 5.0	0.33 - 3.0	None
7.5	5.0	
10 - 15	7.5 - 10	None
20	15	
25	20	
30	25	
40	30	
50	40	

PowerFlex 700 Power Rating		Derating
ND HP	HD HP	2 kHz 4 kHz 6 kHz 8 kHz 10 kHz
240 Volt		
60	50	
75	60	
100	75	

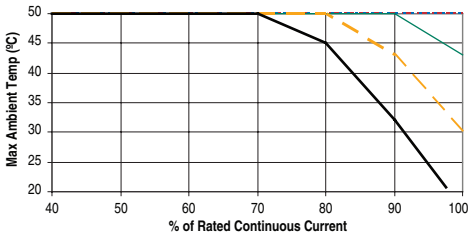
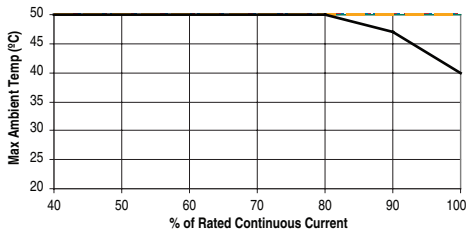
400V AC

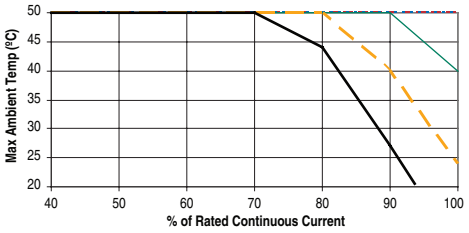
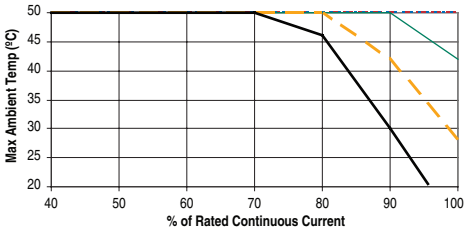
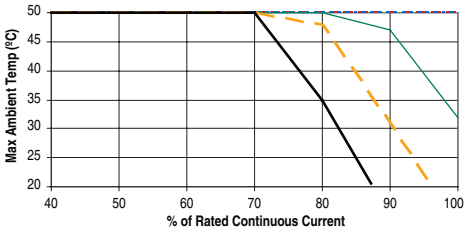
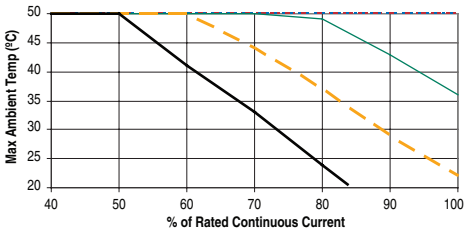
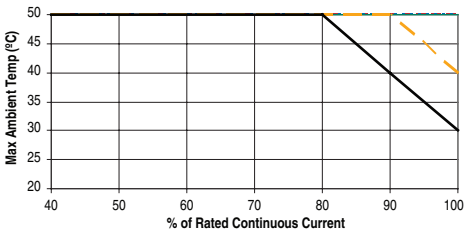
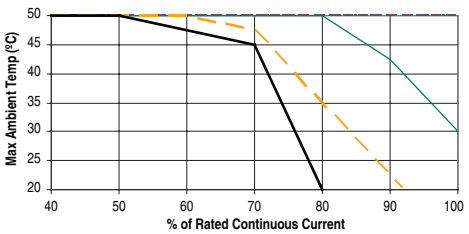
PowerFlex 700 Power Rating		Derating
ND kW	HD kW	2 kHz 4 kHz 6 kHz 8 kHz 10 kHz
400 Volt		
0.37 - 7.5	0.25 - 5.5	None
11	7.5	
15	11	

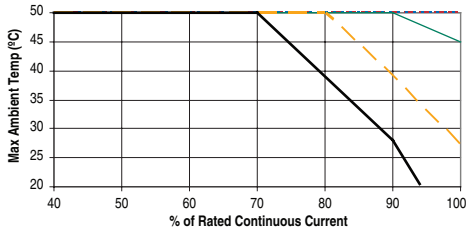
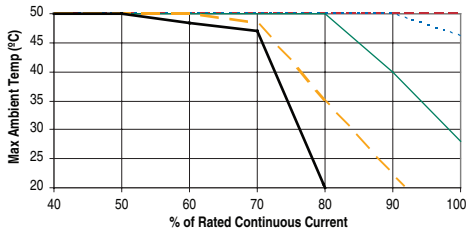
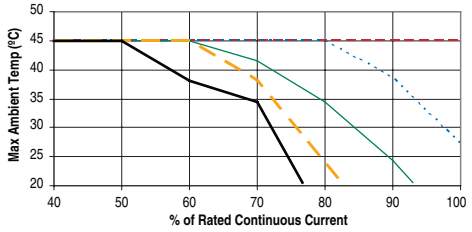
PowerFlex 700 Power Rating		Derating
ND kW	HD kW	2 kHz 4 kHz 6 kHz 8 kHz 10 kHz
400 Volt		
18.5	15	
22	18.5	None
30	22	
37	30	
45	37	
55	45	
75	55	

PowerFlex 700 Power Rating		Derating
ND kW	HD kW	2 kHz 4 kHz 6 kHz 8 kHz 10 kHz
400 Volt		
90	75	
110	90	
132	110	

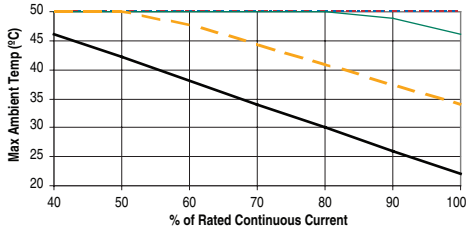
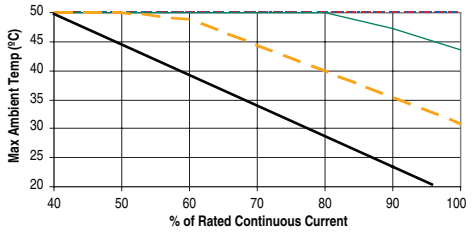
480V AC

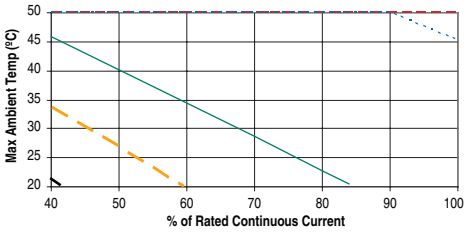
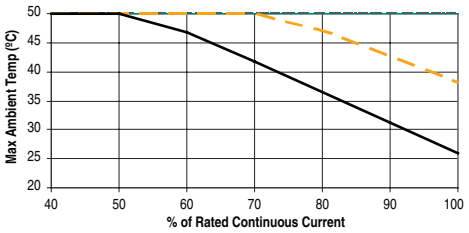
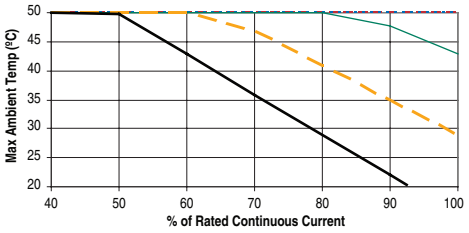
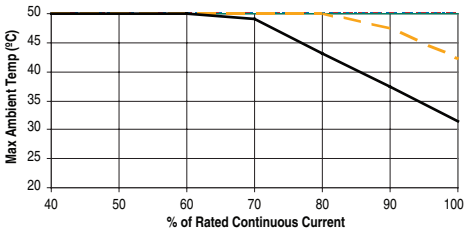
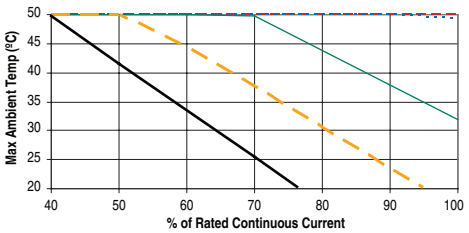
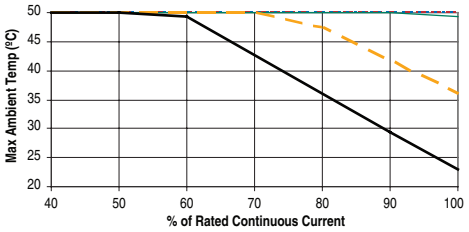
PowerFlex 700 Power Rating		Derating
ND HP	HD HP	2 kHz 4 kHz 6 kHz 8 kHz 10 kHz
480 Volt		
0.5 - 10	0.33 - 7.5	None
15	10	
20	15	

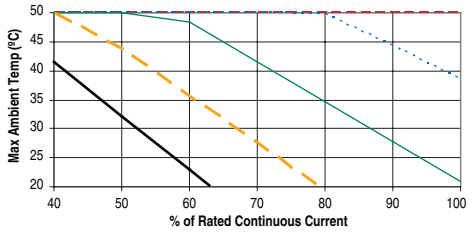
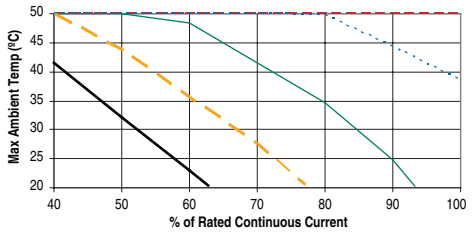
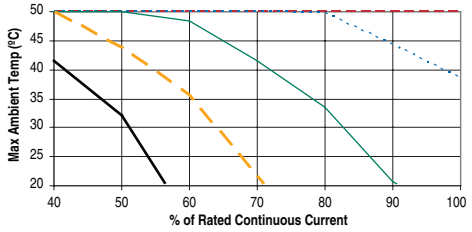
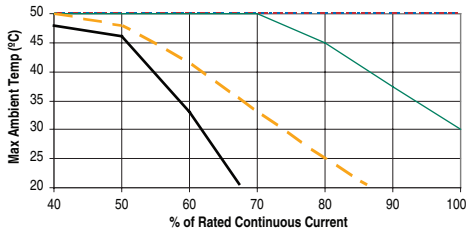
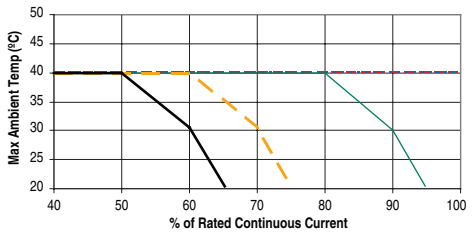
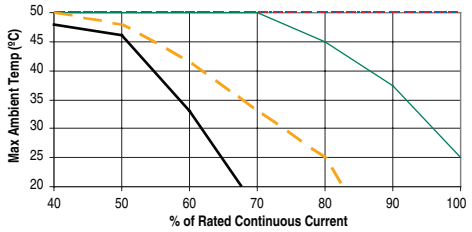
PowerFlex 700 Power Rating		Derating
ND HP	HD HP	2 kHz 4 kHz 6 kHz 8 kHz 10 kHz
480 Volt		
25	20	
30	25	None
40	30	
50	40	
60	50	
75	60	
100	75	

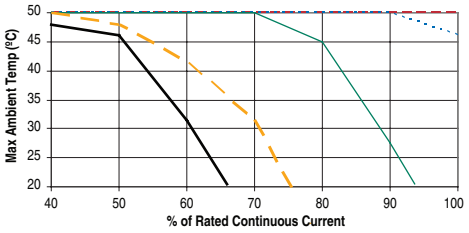
PowerFlex 700 Power Rating		Derating
ND HP	HD HP	2 kHz 4 kHz 6 kHz 8 kHz 10 kHz
480 Volt		
125	100	
150	125	
200	150	

600V AC

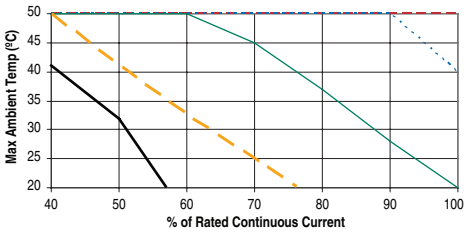
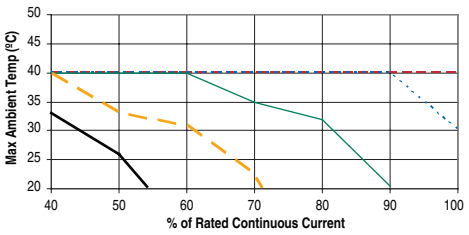
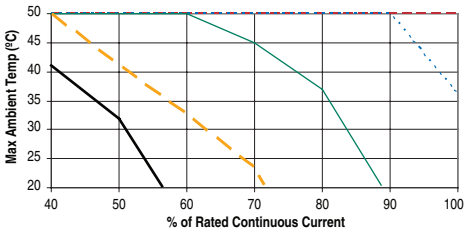
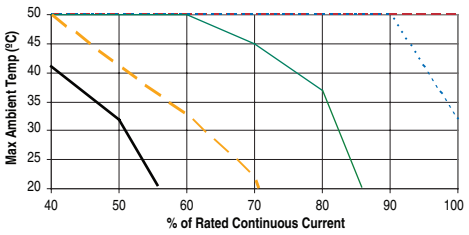
PowerFlex 700 Power Rating		Derating
ND HP	HD HP	2 kHz 4 kHz 6 kHz 8 kHz 10 kHz
600 Volt		
1.0 - 2.0	0.5 - 1.0	None
3.0	2.0	
5.0	3.0	

PowerFlex 700 Power Rating		Derating
ND HP	HD HP	2 kHz 4 kHz 6 kHz 8 kHz 10 kHz
600 Volt		
7.5	5.0	
10	7.5	
15	10	
20	15	
25	20	
30	25	

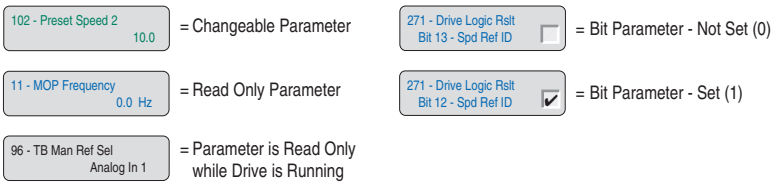
PowerFlex 700 Power Rating		Derating
ND HP	HD HP	2 kHz 4 kHz 6 kHz 8 kHz 10 kHz
600 Volt		
40	30	
50	40	
60	50	
75	60	
100	75	
125	100	

PowerFlex 700 Power Rating		Derating
ND HP	HD HP	2 kHz 4 kHz 6 kHz 8 kHz 10 kHz
600 Volt		
150	125	

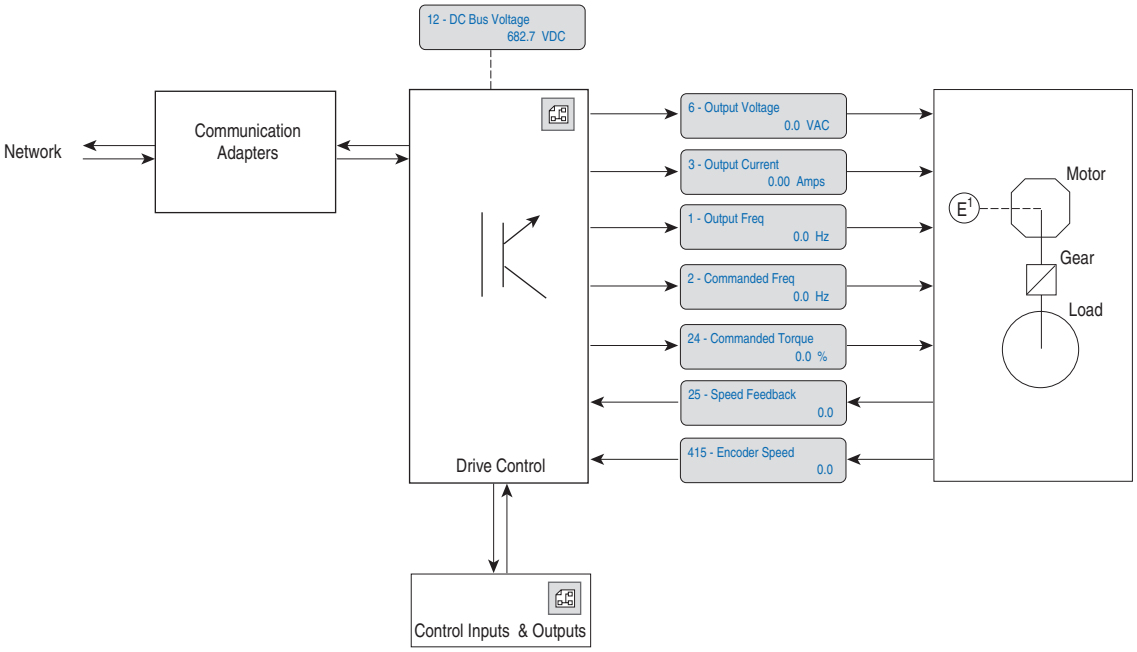
690V AC

PowerFlex 700 Power Rating		Derating
ND kW	HD kW	2 kHz 4 kHz 6 kHz 8 kHz 10 kHz
690 Volt		
45 - 55	37.5 - 45	None
75	55	
90	75	
110	90	
132	110	

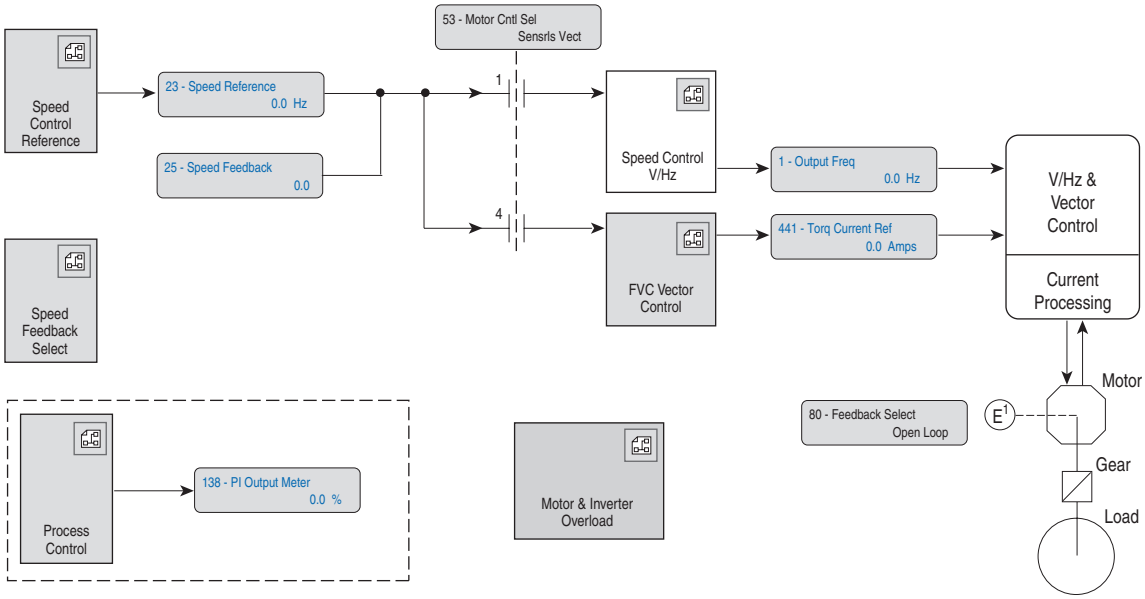
PowerFlex 70EC Block Diagrams


102 - Preset Speed 2
10.0
= Changeable Parameter
11 - MOP Frequency
0.0 Hz
= Read Only Parameter
96 - TB Man Ref Sel
Analog In 1
= Parameter is Read Only while Drive is Running
271 - Drive Logic Rslt
Bit 13 - Spd Ref ID
= Bit Parameter - Not Set (0)
271 - Drive Logic Rslt
Bit 12 - Spd Ref ID
= Bit Parameter - Set (1)

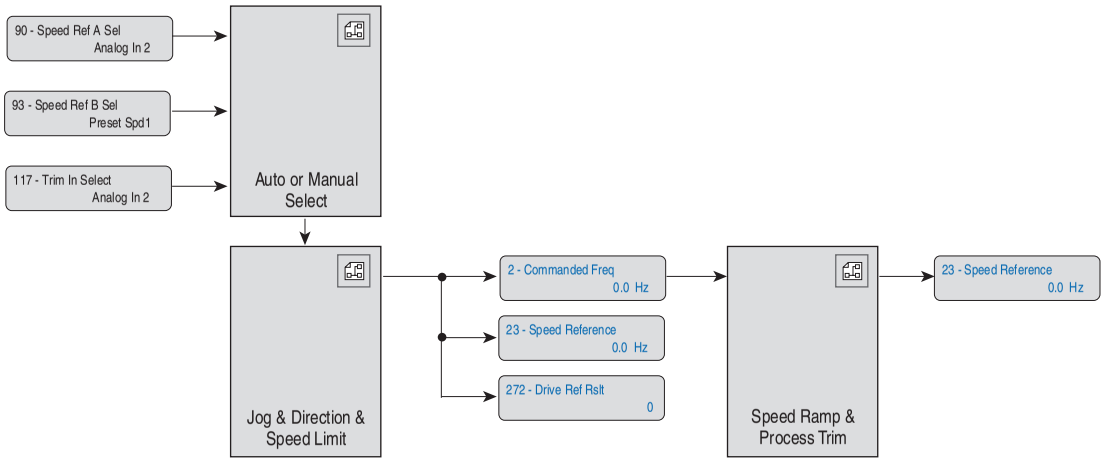
Drive Overview



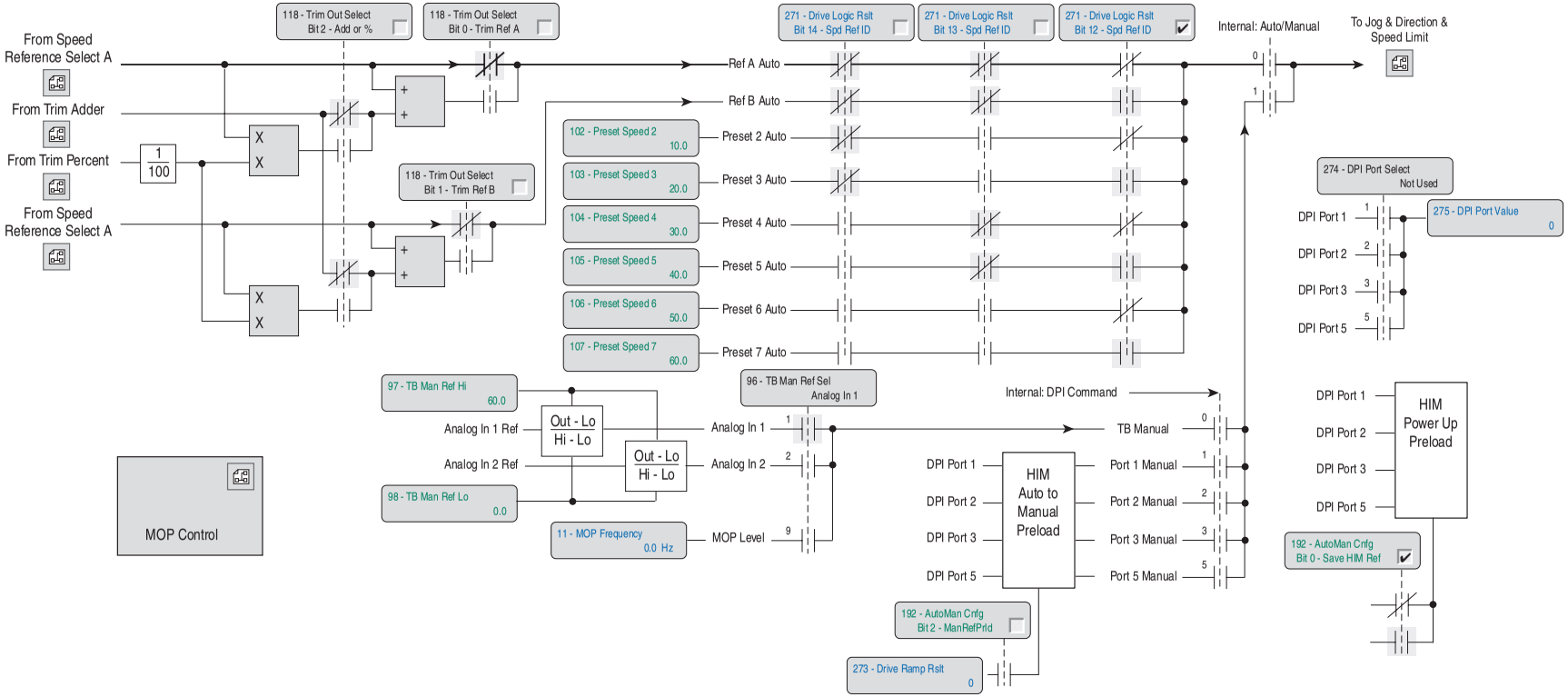
Control Overview



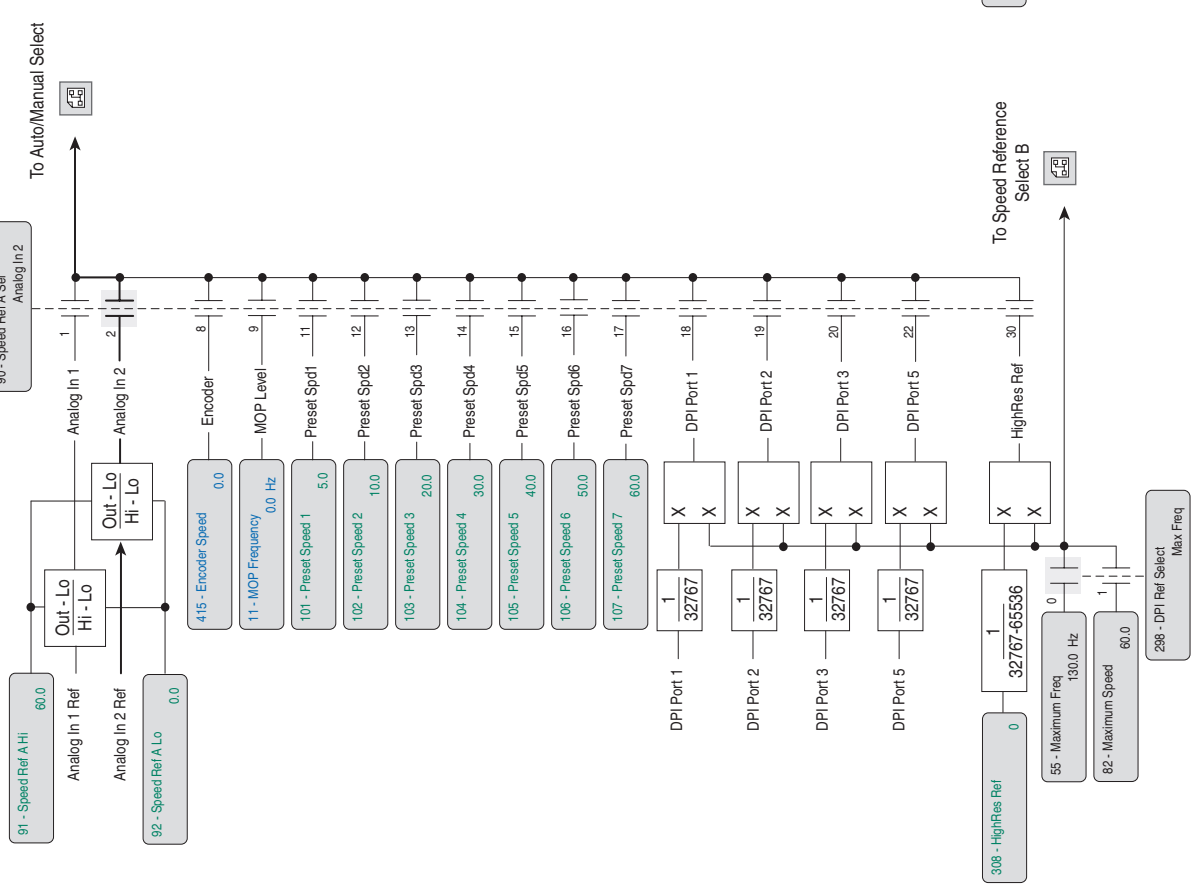
Speed Control Reference Overview



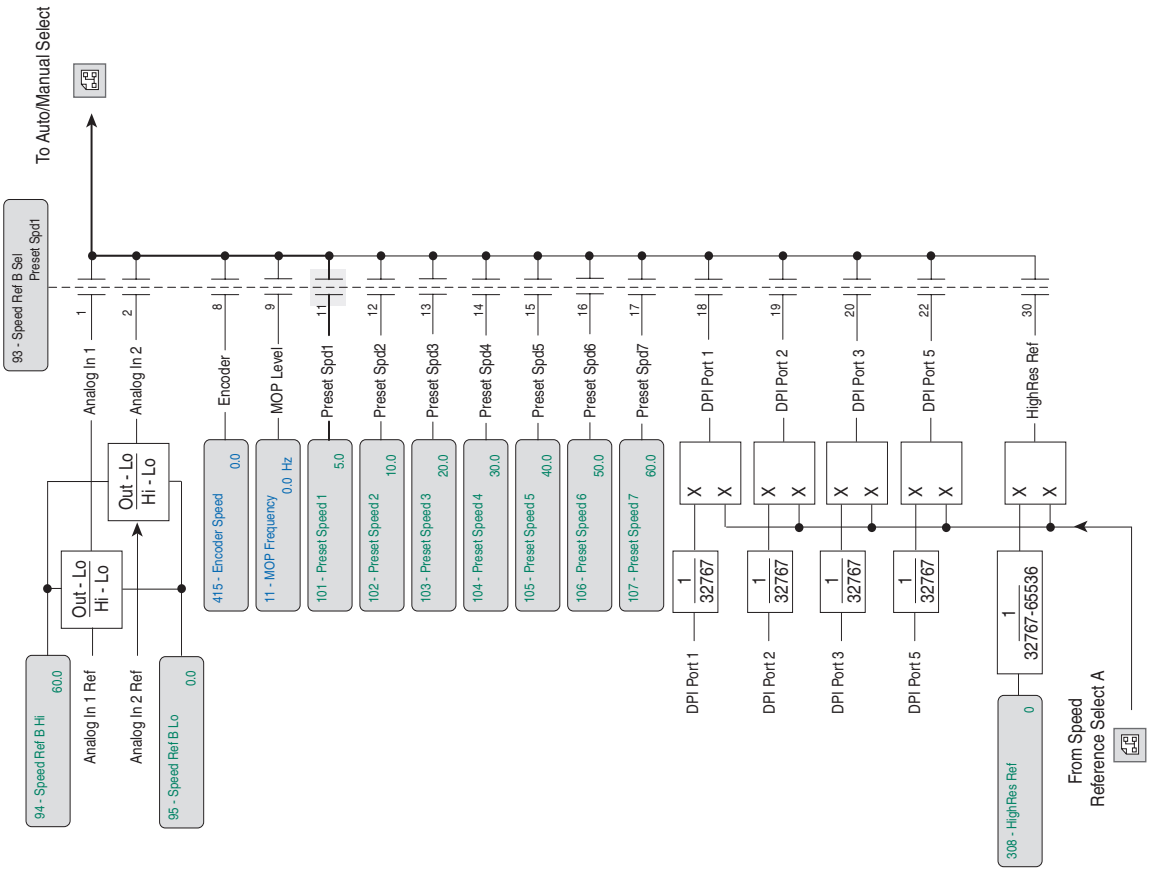
Auto/Manual Select


From Speed Reference Select A
From Trim Adder
From Trim Percent
From Speed Reference Select A
1/100
118 - Trim Out Select Bit 2 - Add or %
118 - Trim Out Select Bit 0 - Trim Ref A
118 - Trim Out Select Bit 1 - Trim Ref B
271 - Drive Logic Rslt Bit 14 - Spd Ref ID
271 - Drive Logic Rslt Bit 13 - Spd Ref ID
271 - Drive Logic Rslt Bit 12 - Spd Ref ID
Internal: Auto/Manual
To Jog & Direction & Speed Limit
Ref A Auto
Ref B Auto
Preset 2 Auto
Preset 3 Auto
Preset 4 Auto
Preset 5 Auto
Preset 6 Auto
Preset 7 Auto
102 - Preset Speed 2 10.0
103 - Preset Speed 3 20.0
104 - Preset Speed 4 30.0
105 - Preset Speed 5 40.0
106 - Preset Speed 6 50.0
107 - Preset Speed 7 60.0
274 - DPI Port Select Not Used
275 - DPI Port Value 0
DPI Port 1
DPI Port 2
DPI Port 3
DPI Port 5
97 - TB Man Ref Hi 60.0
98 - TB Man Ref Lo 0.0
Analog In 1 Ref
Analog In 2 Ref
Out - Lo Hi - Lo
96 - TB Man Ref Sel Analog In 1
Analog In 1
Analog In 2
MOP Level
11 - MOP Frequency 0.0 Hz
MOP Control
Internal: DPI Command
TB Manual
Port 1 Manual
Port 2 Manual
Port 3 Manual
Port 5 Manual
HIM Auto to Manual Preload
HIM Power Up Preload
192 - AutoMan Cnfg Bit 0 - Save HIM Ref
192 - AutoMan Cnfg Bit 2 - ManRefPrld
273 - Drive Ramp Rslt 0

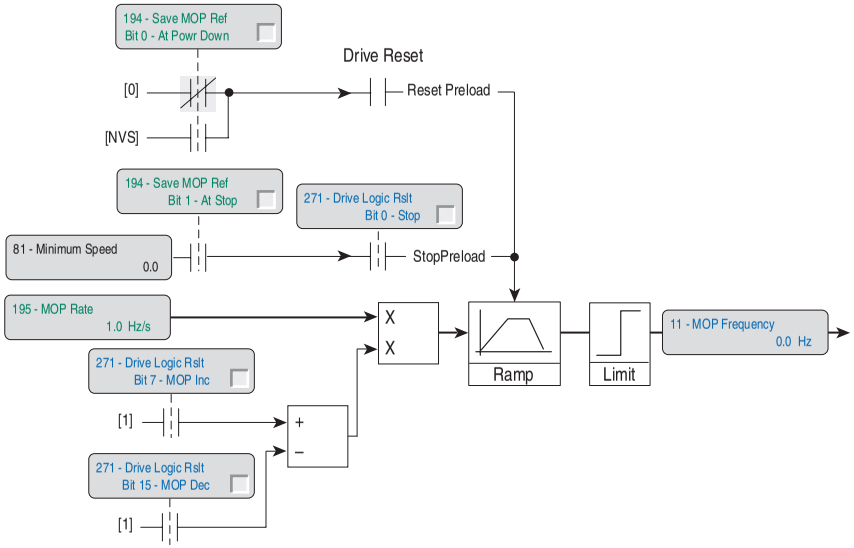
Speed Reference A Select



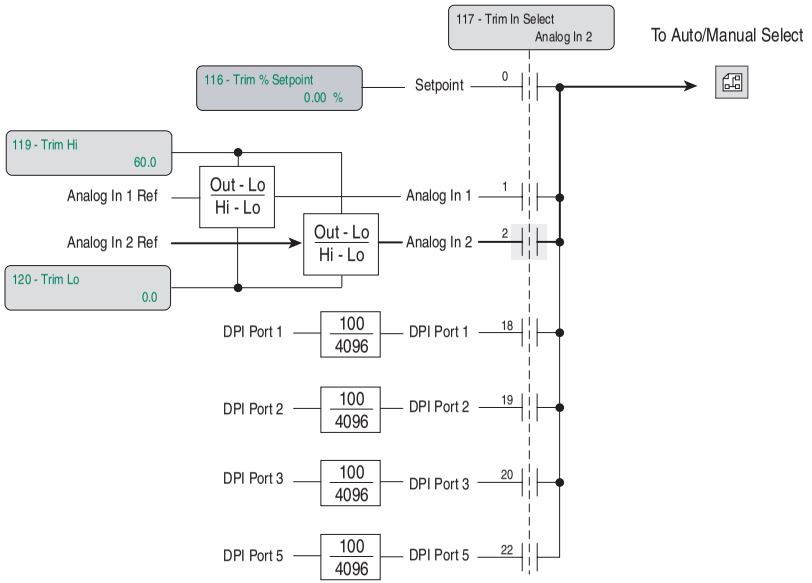
Speed Reference B Select



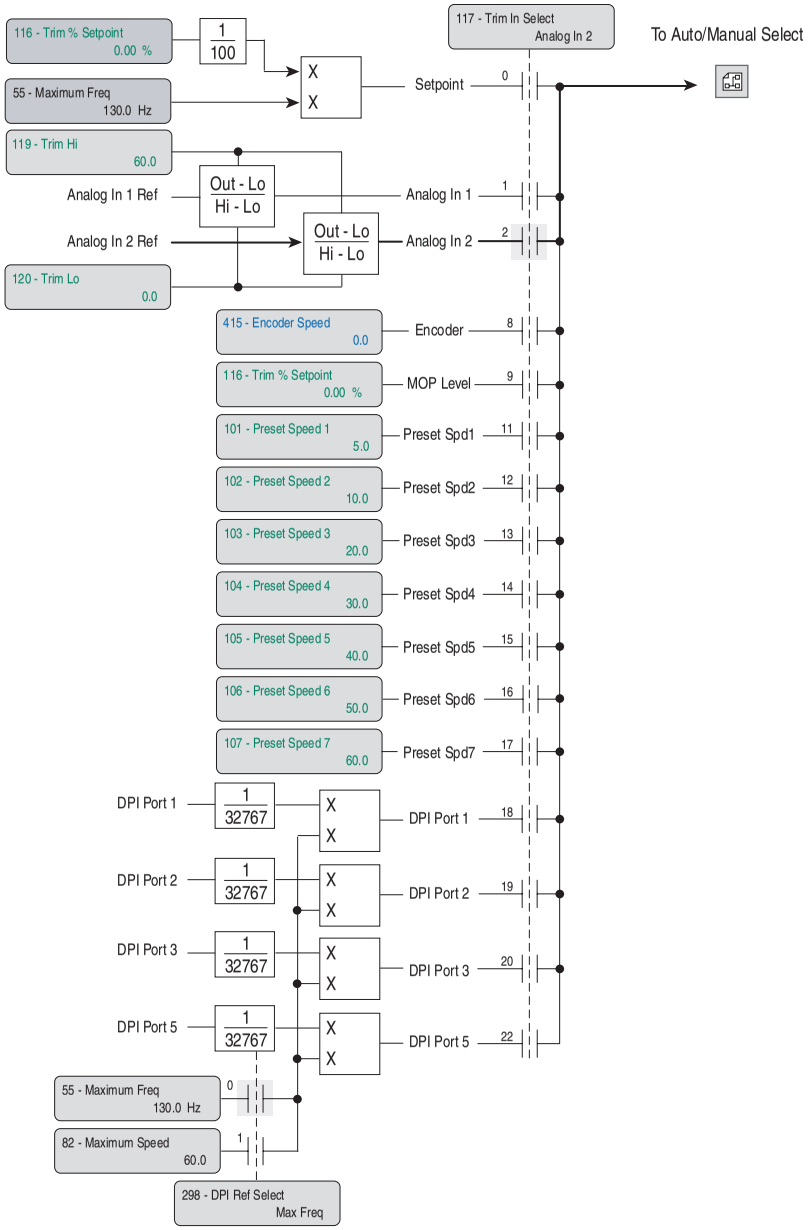
MOP Select



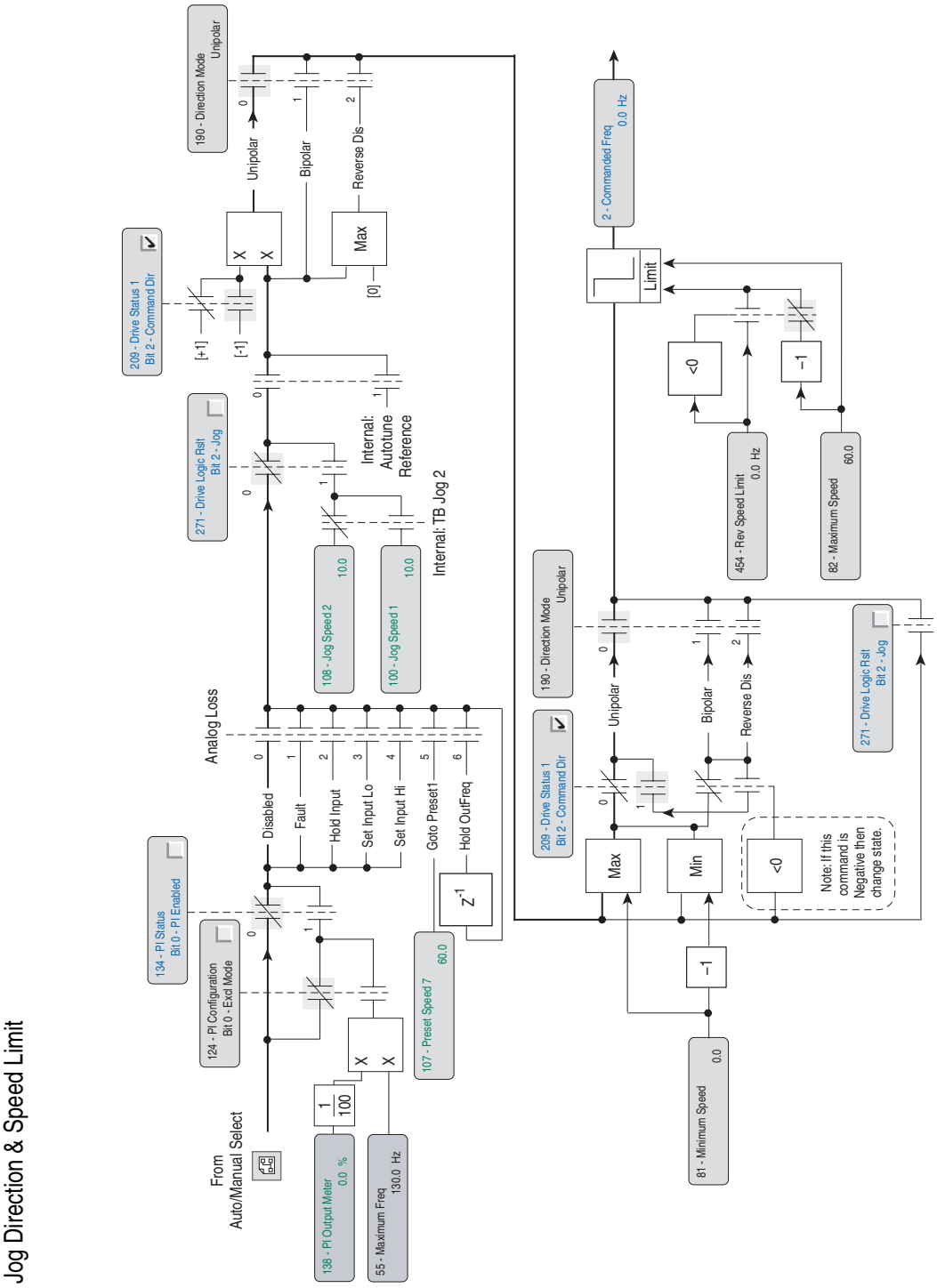
Trim Select



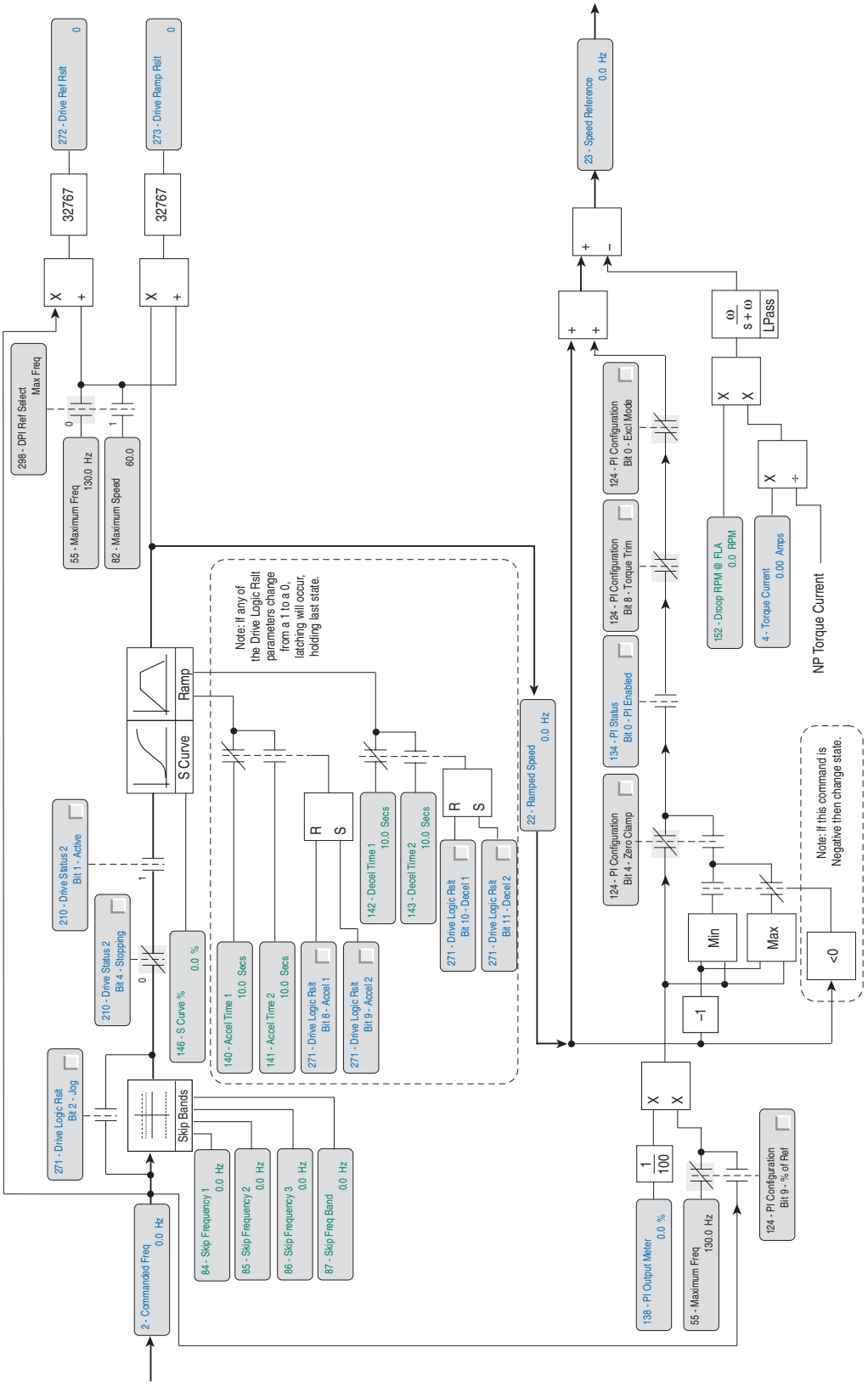
Trim Select



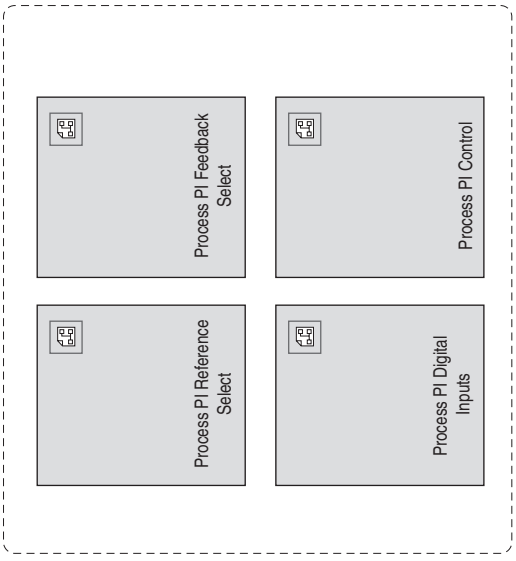
Jog Direction & Speed Limit



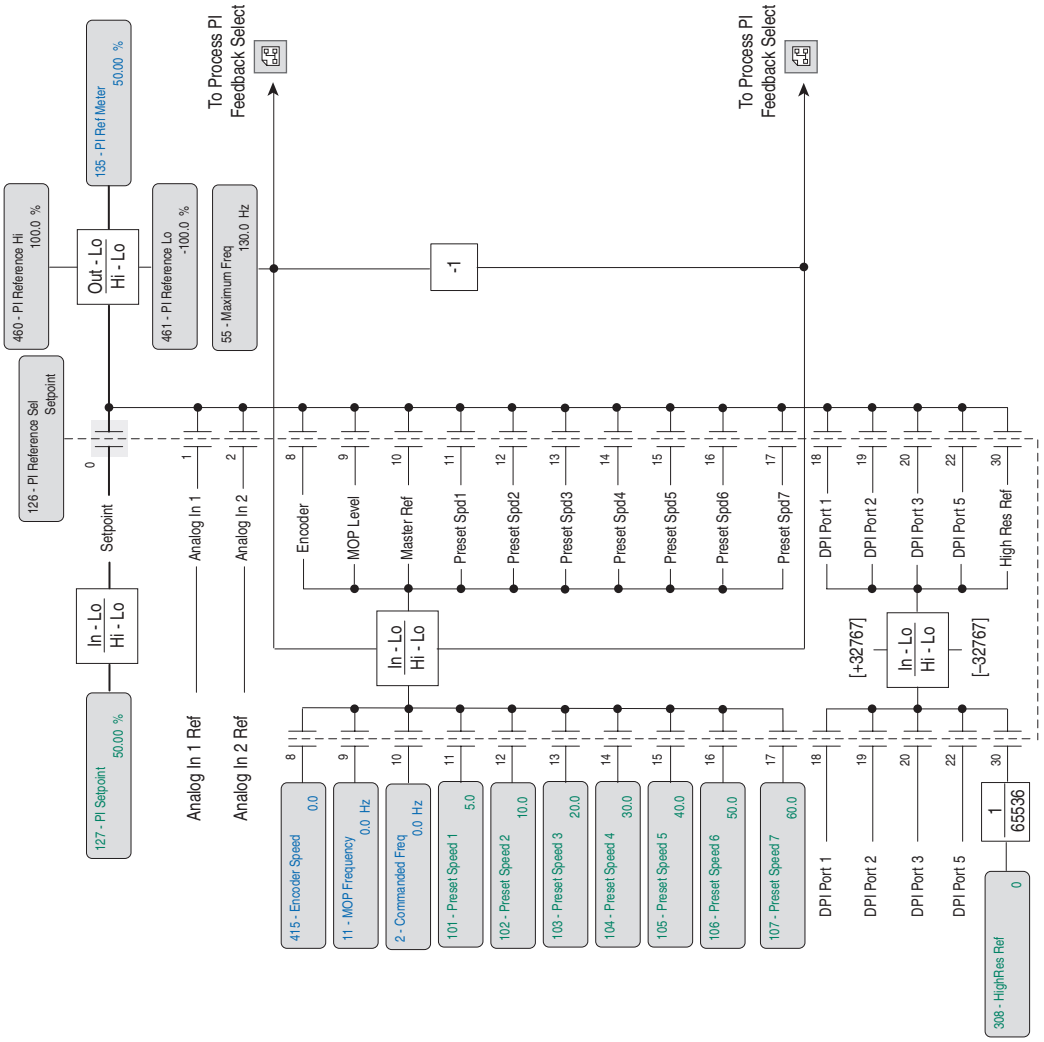
Speed Ramp & Process Trim

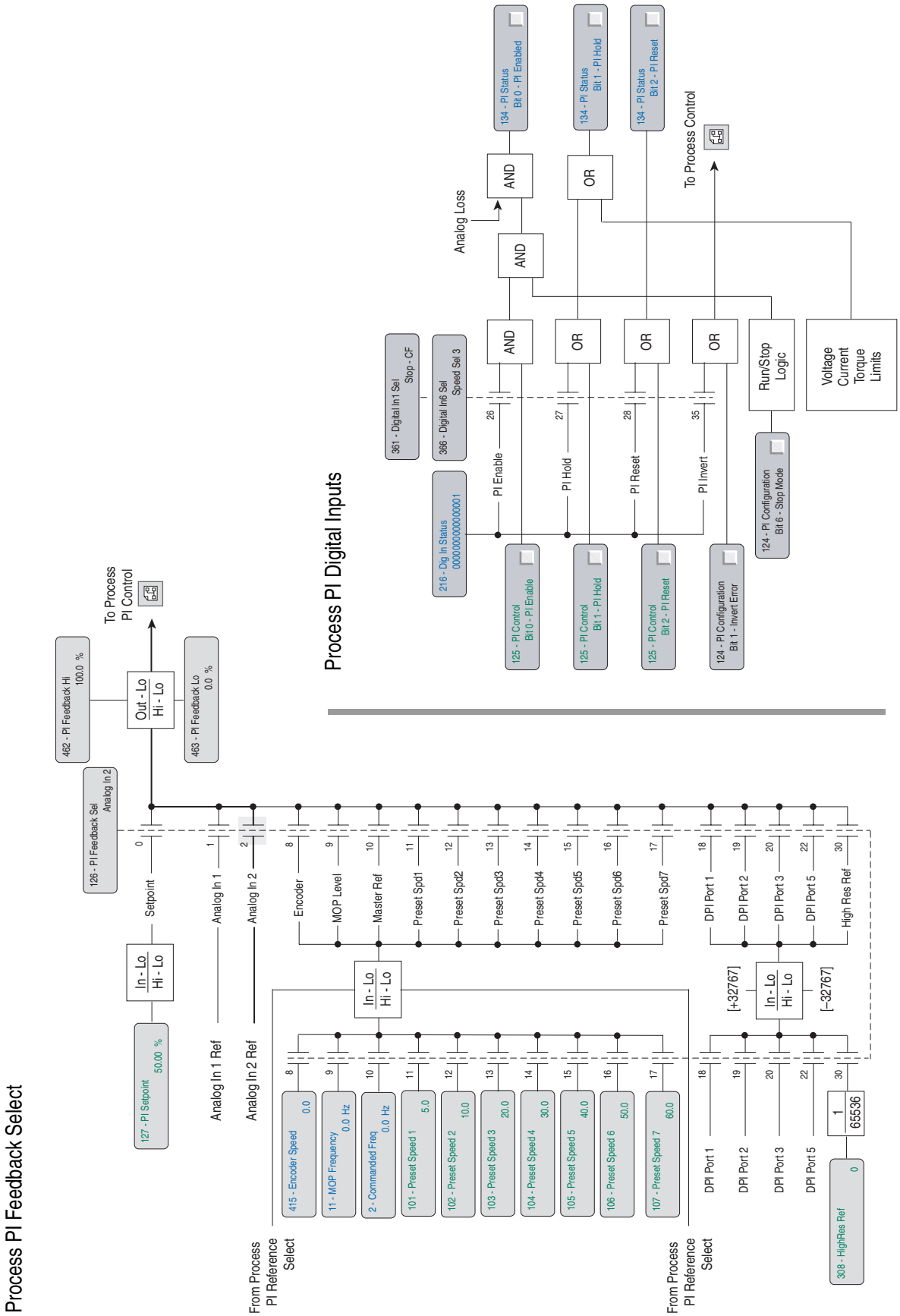

2 - Commanded Freq 0.0 Hz
271 - Drive Logic Rslt Bit 2 - Jog
Skip Bands
84 - Skip Frequency 1 0.0 Hz
85 - Skip Frequency 2 0.0 Hz
86 - Skip Frequency 3 0.0 Hz
87 - Skip Freq Band 0.0 Hz
210 - Drive Status 2 Bit 1 - Active
210 - Drive Status 2 Bit 4 - Stopping
146 - S Curve % 0.0 %
S Curve
Ramp
140 - Accel Time 1 10.0 Secs
141 - Accel Time 2 10.0 Secs
271 - Drive Logic Rslt Bit 8 - Accel 1
271 - Drive Logic Rslt Bit 9 - Accel 2
142 - Decel Time 1 10.0 Secs
143 - Decel Time 2 10.0 Secs
271 - Drive Logic Rslt Bit 10 - Decel 1
271 - Drive Logic Rslt Bit 11 - Decel 2
Note: If any of the Drive Logic Rslt parameters change from a 1 to a 0, latching will occur, holding last state.
22 - Ramped Speed 0.0 Hz
298 - DPI Ref Select Max Freq
55 - Maximum Freq 130.0 Hz
82 - Maximum Speed 60.0
272 - Drive Ref Rslt 0
273 - Drive Ramp Rslt 0
32767
32767
23 - Speed Reference 0.0 Hz
124 - PI Configuration Bit 0 - Excl Mode
124 - PI Configuration Bit 8 - Torque Trim
134 - PI Status Bit 0 - PI Enabled
124 - PI Configuration Bit 4 - Zero Clamp
Min
Max
-1
<0
Note: If this command is Negative then change state.
ω / s + ω LPass
152 - Droop RPM @ FLA 0.0 RPM
4 - Torque Current 0.00 Amps
NP Torque Current
1 / 100
138 - PI Output Meter 0.0 %
55 - Maximum Freq 130.0 Hz
124 - PI Configuration Bit 9 - % of Pref

Process PI Overview

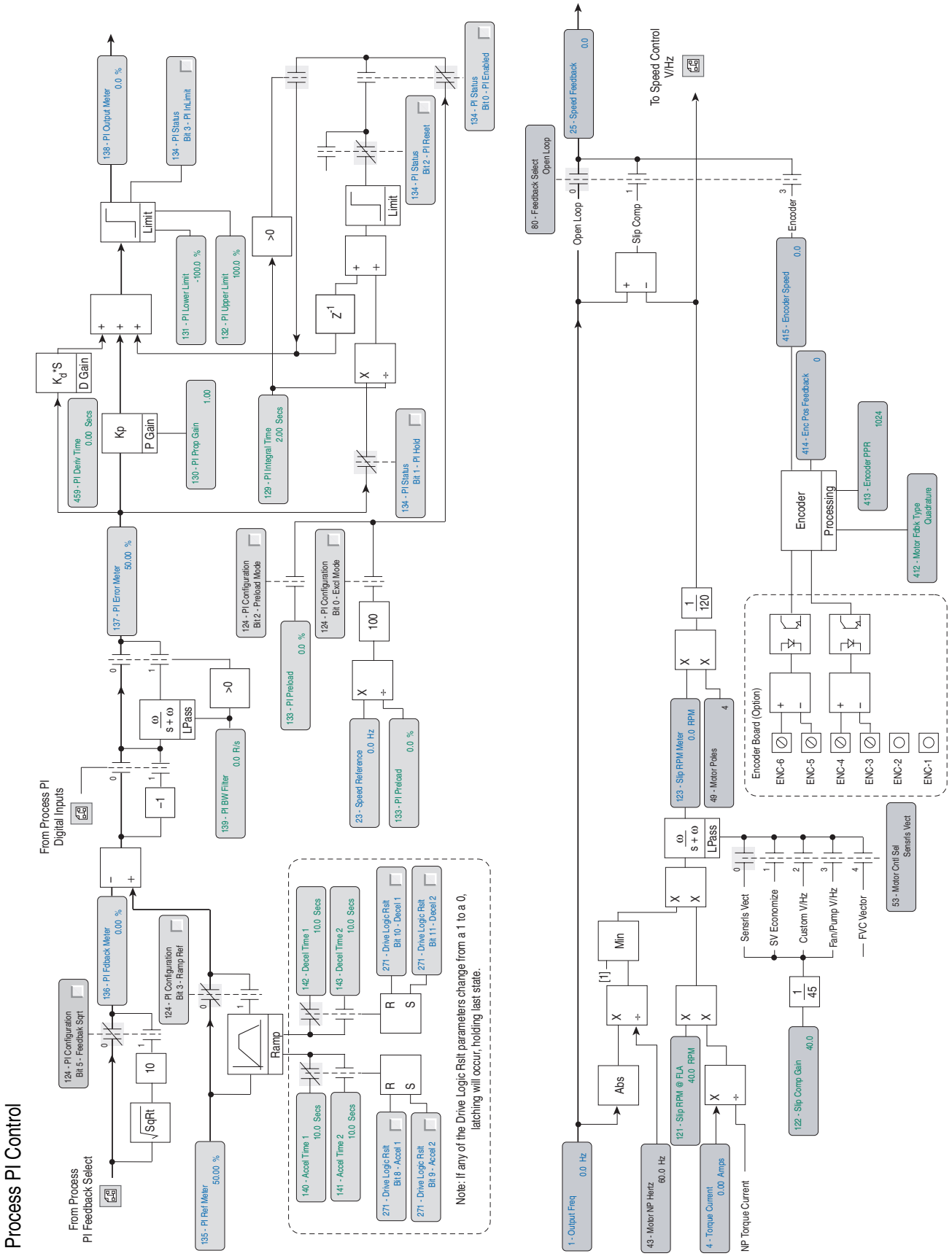


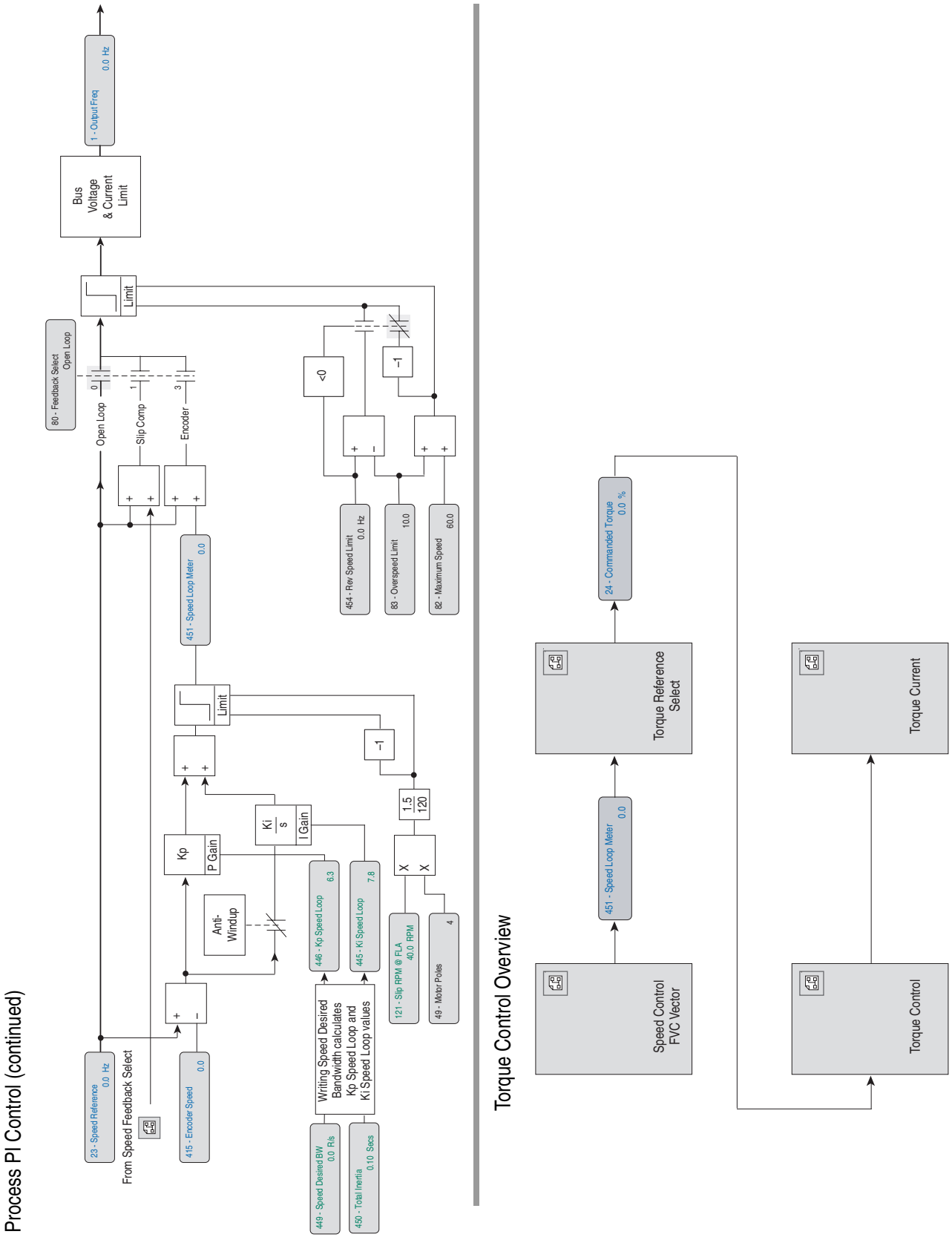
Process PI Reference Select



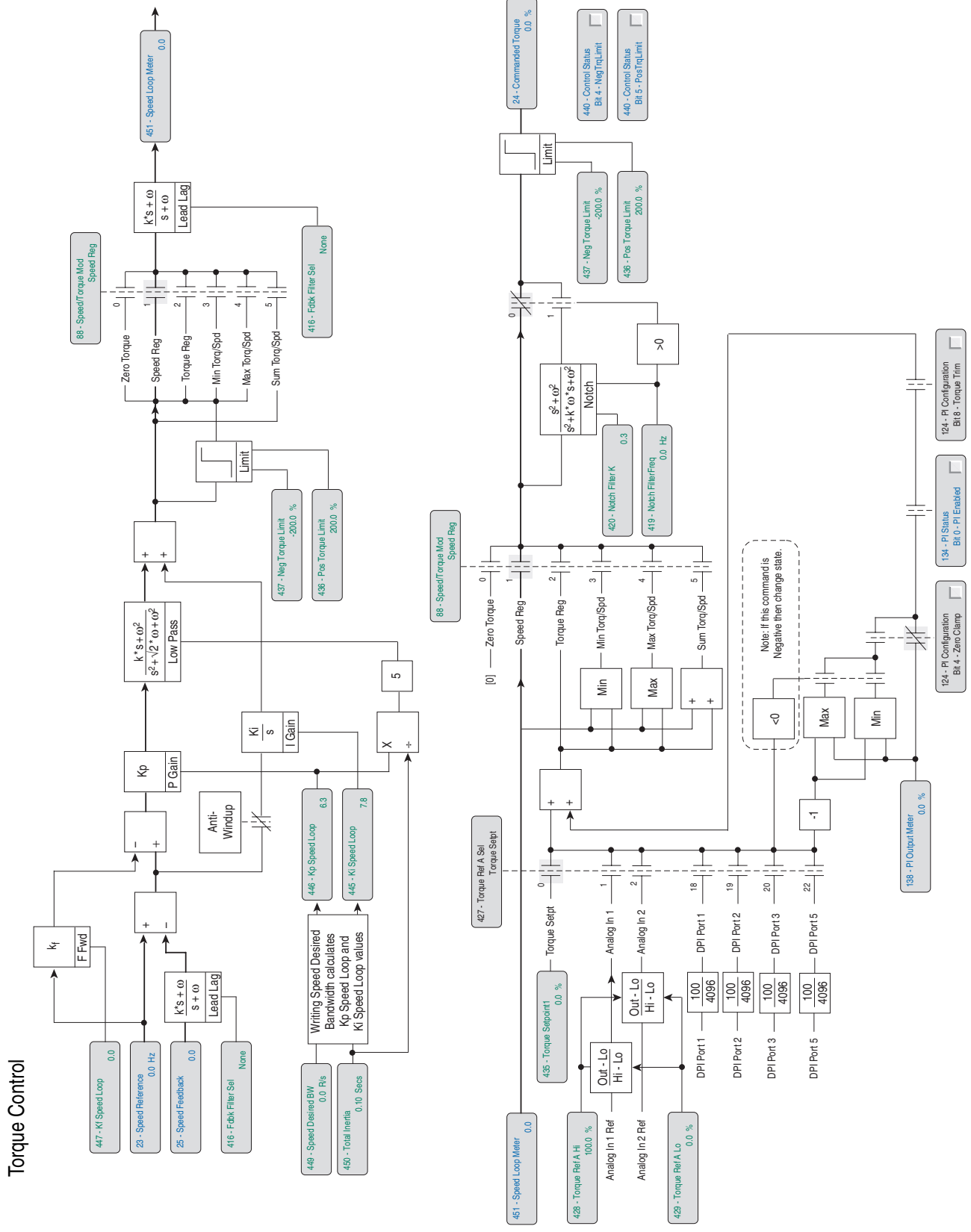

Process PI Feedback Select
126 - PI Feedback Sel
Analog In 2
462 - PI Feedback Hi
100.0 %
463 - PI Feedback Lo
0.0 %
Out - Lo
Hi - Lo
To Process
PI Control
In - Lo
Hi - Lo
127 - PI Setpoint
50.00 %
0 Setpoint
1 Analog In 1
2 Analog In 2
Analog In 1 Ref
Analog In 2 Ref
From Process
PI Reference
Select
8 Encoder
9 MOP Level
10 Master Ref
11 Preset Spd1
12 Preset Spd2
13 Preset Spd3
14 Preset Spd4
15 Preset Spd5
16 Preset Spd6
17 Preset Spd7
415 - Encoder Speed 0.0
11 - MOP Frequency 0.0 Hz
2 - Commanded Freq 0.0 Hz
101 - Preset Speed 1 5.0
102 - Preset Speed 2 10.0
103 - Preset Speed 3 20.0
104 - Preset Speed 4 30.0
105 - Preset Speed 5 40.0
106 - Preset Speed 6 50.0
107 - Preset Speed 7 60.0
18 DPI Port 1
19 DPI Port 2
20 DPI Port 3
22 DPI Port 5
30 High Res Ref
[+32767]
[-32767]
1
65536
308 - HighRes Ref 0
Process PI Digital Inputs
361 - Digital In1 Sel
Stop - CF
366 - Digital In6 Sel
Speed Sel 3
216 - Dig In Status
0000000000000001
26 PI Enable
27 PI Hold
28 PI Reset
35 PI Invert
AND
OR
Analog Loss
125 - PI Control
Bit 0 - PI Enable
125 - PI Control
Bit 1 - PI Hold
125 - PI Control
Bit 2 - PI Reset
124 - PI Configuration
Bit 1 - Invert Error
134 - PI Status
Bit 0 - PI Enabled
134 - PI Status
Bit 1 - PI Hold
134 - PI Status
Bit 2 - PI Reset
To Process Control
124 - PI Configuration
Bit 6 - Stop Mode
Run/Stop
Logic
Voltage
Current
Torque
Limits

Process PI Control

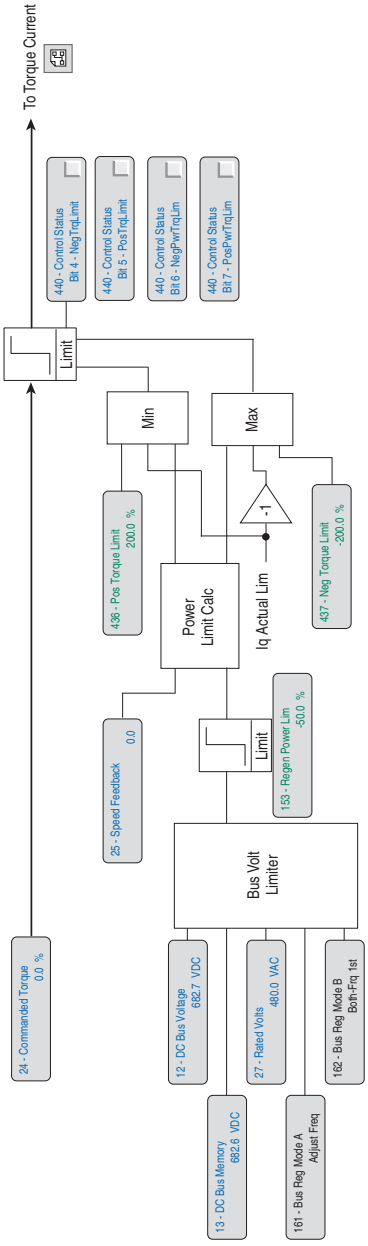

From Process PI Feedback Select
From Process PI Digital Inputs
124 - PI Configuration Bit 5 - Feedbak Sqrt
136 - PI Fdback Meter 0.00 %
124 - PI Configuration Bit 3 - Ramp Ref
135 - PI Ref Meter 50.00 %
SqRt
10
Ramp
140 - Accel Time 1 10.0 Secs
141 - Accel Time 2 10.0 Secs
142 - Decel Time 1 10.0 Secs
143 - Decel Time 2 10.0 Secs
271 - Drive Logic Rslt Bit 8 - Accel 1
271 - Drive Logic Rslt Bit 9 - Accel 2
271 - Drive Logic Rslt Bit 10 - Decel 1
271 - Drive Logic Rslt Bit 11 - Decel 2
Note: If any of the Drive Logic Rslt parameters change from a 1 to a 0, latching will occur, holding last state.
139 - PI BW Filter 0.0 R/s
LPass
459 - PI Deriv Time 0.00 Secs
D Gain
Kp
P Gain
130 - PI Prop Gain 1.00
131 - PI Lower Limit -100.0 %
132 - PI Upper Limit 100.0 %
Limit
138 - PI Output Meter 0.0 %
134 - PI Status Bit 3 - PI InLimit
137 - PI Error Meter 50.00 %
129 - PI Integral Time 2.00 Secs
134 - PI Status Bit 1 - PI Hold
134 - PI Status Bit 2 - PI Reset
134 - PI Status Bit 0 - PI Enabled
124 - PI Configuration Bit 2 - Preload Mode
133 - PI Preload 0.0 %
124 - PI Configuration Bit 0 - Excl Mode
100
23 - Speed Reference 0.0 Hz
133 - PI Preload 0.0 %
80 - Feedback Select Open Loop
25 - Speed Feedback 0.0
To Speed Control V/Hz
Open Loop
Slip Comp
Encoder
1 - Output Freq 0.0 Hz
Abs
Min
43 - Motor NP Hertz 60.0 Hz
121 - Slip RPM @ FLA 40.0 RPM
4 - Torque Current 0.00 Amps
NP Torque Current
123 - Slip RPM Meter 0.0 RPM
49 - Motor Poles 4
122 - Slip Comp Gain 40.0
Sensrls Vect
SV Economize
Custom V/Hz
Fan/Pump V/Hz
FVC Vector
53 - Motor Cntl Sel Sensrls Vect
Encoder Board (Option)
ENC-6
ENC-5
ENC-4
ENC-3
ENC-2
ENC-1
415 - Encoder Speed 0.0
414 - Enc Pos Feedback 0
413 - Encoder PPR 1024
412 - Motor Fdbk Type Quadrature
Processing


Process PI Control (continued)
23 - Speed Reference 0.0 Hz
From Speed Feedback Select
415 - Encoder Speed 0.0
80 - Feedback Select Open Loop
Open Loop
Slip Comp
Encoder
451 - Speed Loop Meter 0.0
Kp
P Gain
Ki
s
I Gain
Anti-Windup
Limit
Bus Voltage & Current Limit
1 - Output Freq 0.0 Hz
Writing Speed Desired Bandwidth calculates Kp Speed Loop and Ki Speed Loop values
449 - Speed Desired BW 0.0 Rad/s
450 - Total Inertia 0.10 Secs
446 - Kp Speed Loop 6.3
445 - Ki Speed Loop 7.8
121 - Slip RPM @ FLA 40.0 RPM
49 - Motor Poles 4
1.5 / 120
<0
454 - Rev Speed Limit 0.0 Hz
83 - Overspeed Limit 10.0
82 - Maximum Speed 60.0
Torque Control Overview
Speed Control FVC Vector
451 - Speed Loop Meter 0.0
Torque Reference Select
24 - Commanded Torque 0.0 %
Torque Control
Torque Current

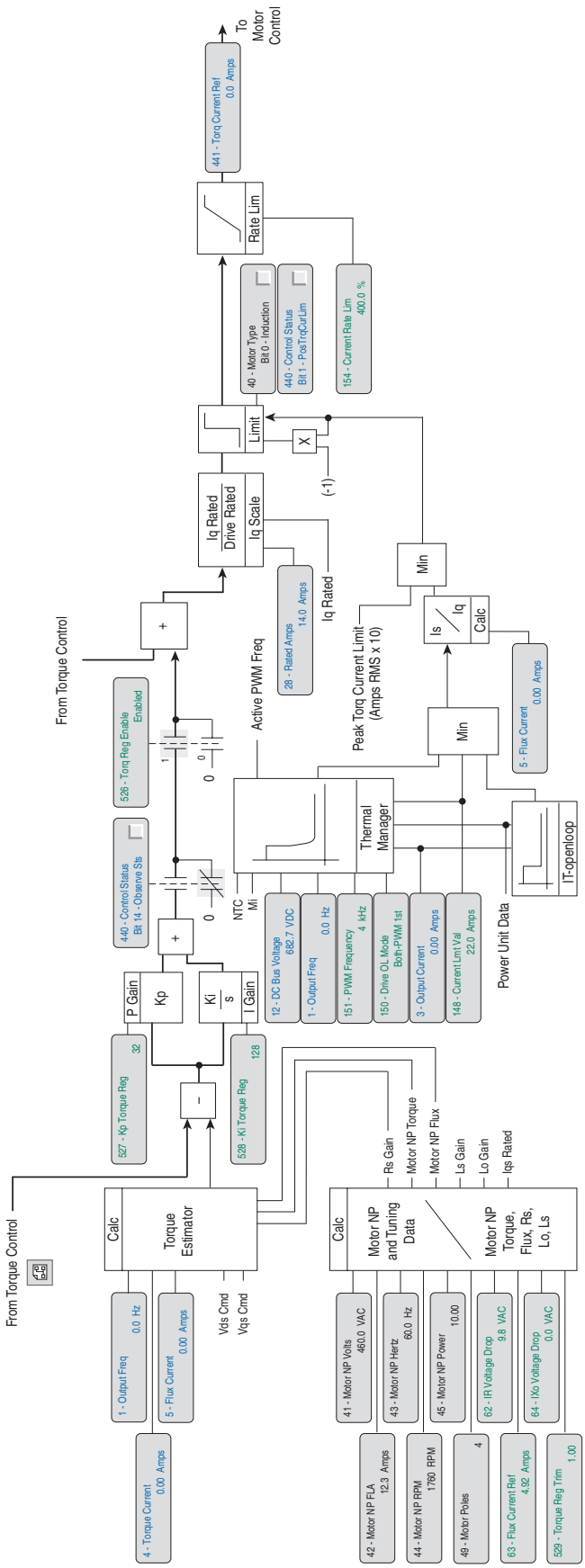
Torque Control


447 - Kf Speed Loop 0.0
23 - Speed Reference 0.0 Hz
25 - Speed Feedback 0.0
416 - Fdbk Filter Sel None
449 - Speed Desired BW 0.0 R/s
450 - Total Inertia 0.10 Secs
Writing Speed Desired Bandwidth calculates Kp Speed Loop and Ki Speed Loop values
446 - Kp Speed Loop 6.3
445 - Ki Speed Loop 7.8
Kf F Fwd
Kp P Gain
Ki/s I Gain
Anti-Windup
5
k*s+ω²/s²+√2*ω+ω² Low Pass
k*s+ω/s+ω Lead Lag
Limit
437 - Neg Torque Limit -200.0 %
436 - Pos Torque Limit 200.0 %
88 - Speed/Torque Mod Speed Reg
Zero Torque
Speed Reg
Torque Reg
Min Torq/Spd
Max Torq/Spd
Sum Torq/Spd
416 - Fdbk Filter Sel None
451 - Speed Loop Meter 0.0
24 - Commanded Torque 0.0 %
440 - Control Status Bit 4 - NegTrqLimit
440 - Control Status Bit 5 - PosTrqLimit
437 - Neg Torque Limit -200.0 %
436 - Pos Torque Limit 200.0 %
s²+ω²/s²+k*ω*s+ω² Notch
420 - Notch Filter K 0.3
419 - Notch Filter Freq 0.0 Hz
>0
88 - Speed/Torque Mod Speed Reg
[0] Zero Torque
Speed Reg
Torque Reg
Min Torq/Spd
Max Torq/Spd
Sum Torq/Spd
Min
Max
Note: If this command is Negative then change state.
<0
Max
Min
-1
124 - PI Configuration Bit 8 - Torque Trim
134 - PI Status Bit 0 - PI Enabled
124 - PI Configuration Bit 4 - Zero Clamp
138 - PI Output Meter 0.0 %
427 - Torque Ref A Sel Torque Setpt
0 Torque Setpt
1 Analog In 1
2 Analog In 2
18 DPI Port 1
19 DPI Port 2
20 DPI Port 3
22 DPI Port 5
435 - Torque Setpoint1 0.0 %
Out - Lo Hi - Lo
100/4096
-100/4096
451 - Speed Loop Meter 0.0
428 - Torque Ref A Hi 100.0 %
Analog In 1 Ref
Analog In 2 Ref
429 - Torque Ref A Lo 0.0 %
DPI Port 1
DPI Port 2
DPI Port 3
DPI Port 5

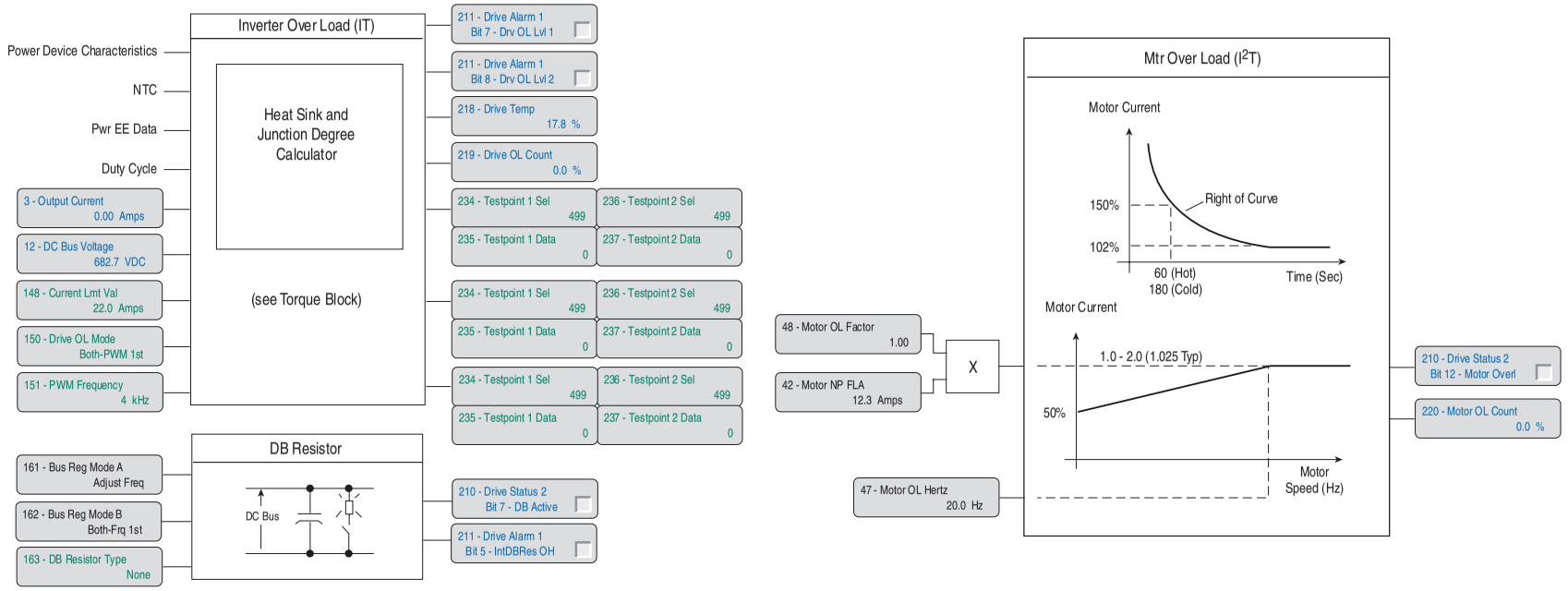
Torque Control (continued)


To Torque Current
24 - Commanded Torque 0.0 %
Limit
440 - Control Status Bit 4 - NegTrqLimit
440 - Control Status Bit 5 - PosTrqLimit
440 - Control Status Bit 6 - NegPwrTrqLim
440 - Control Status Bit 7 - PosPwrTrqLim
Min
Max
436 - Pos Torque Limit 200.0 %
Power Limit Calc
Iq Actual Lim
-1
437 - Neg Torque Limit -200.0 %
25 - Speed Feedback 0.0
Limit
153 - Regen Power Lim -50.0 %
Bus Volt Limiter
12 - DC Bus Voltage 682.7 VDC
27 - Rated Volts 480.0 VAC
162 - Bus Reg Mode B Both-Frq 1st
13 - DC Bus Memory 682.6 VDC
161 - Bus Reg Mode A Adjust Freq

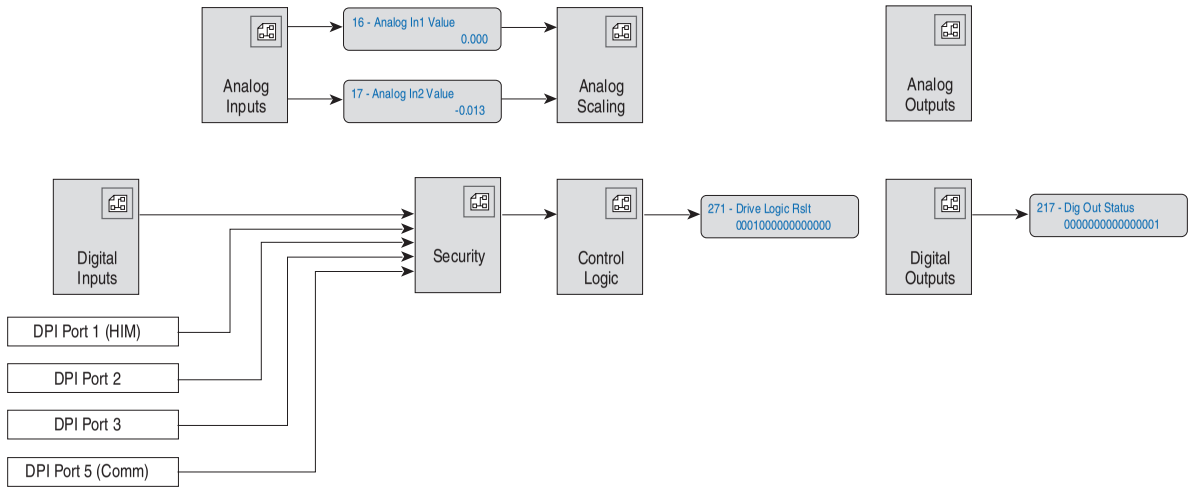
Torque Current


From Torque Control
From Torque Control
441 - Torq Current Ref 0.0 Amps
To Motor Control
Rate Lim
Limit
X
(-1)
40 - Motor Type Bit 0 - Induction
440 - Control Status Bit 1 - PosTrqCurLim
154 - Current Rate Lim 400.0 %
Iq Rated Drive Rated
Iq Scale
28 - Rated Amps 14.0 Amps
Iq Rated
Min
Is / Iq Calc
Peak Torq Current Limit (Amps RMS x 10)
Min
5 - Flux Current 0.00 Amps
Active PWM Freq
Thermal Manager
IT-openloop
Power Unit Data
528 - Torq Reg Enable Enabled
440 - Control Status Bit 14 - Observe Sts
NTC
Mi
12 - DC Bus Voltage 682.7 VDC
1 - Output Freq 0.0 Hz
151 - PWM Frequency 4 kHz
150 - Drive Ctl Mode Both-PWM 1st
3 - Output Current 0.00 Amps
148 - Current Lmt Val 22.0 Amps
P Gain
Kp
Ki / s
I Gain
527 - Kp Torque Reg 32
528 - Ki Torque Reg 128
Calc
Torque Estimator
Vds Cmd
Vqs Cmd
Rs Gain
Motor NP Torque
Motor NP Flux
Ls Gain
Lo Gain
Iqs Rated
Calc
Motor NP and Tuning Data
Motor NP Torque, Flux, Rs, Lo, Ls
1 - Output Freq 0.0 Hz
5 - Flux Current 0.00 Amps
4 - Torque Current 0.00 Amps
41 - Motor NP Volts 460.0 VAC
43 - Motor NP Hertz 60.0 Hz
45 - Motor NP Power 10.00
62 - IR Voltage Drop 9.8 VAC
64 - IXo Voltage Drop 0.0 VAC
42 - Motor NP FLA 12.3 Amps
44 - Motor NP RPM 1760 RPM
49 - Motor Poles 4
63 - Flux Current Ref 4.92 Amps
529 - Torque Reg Trim 1.00

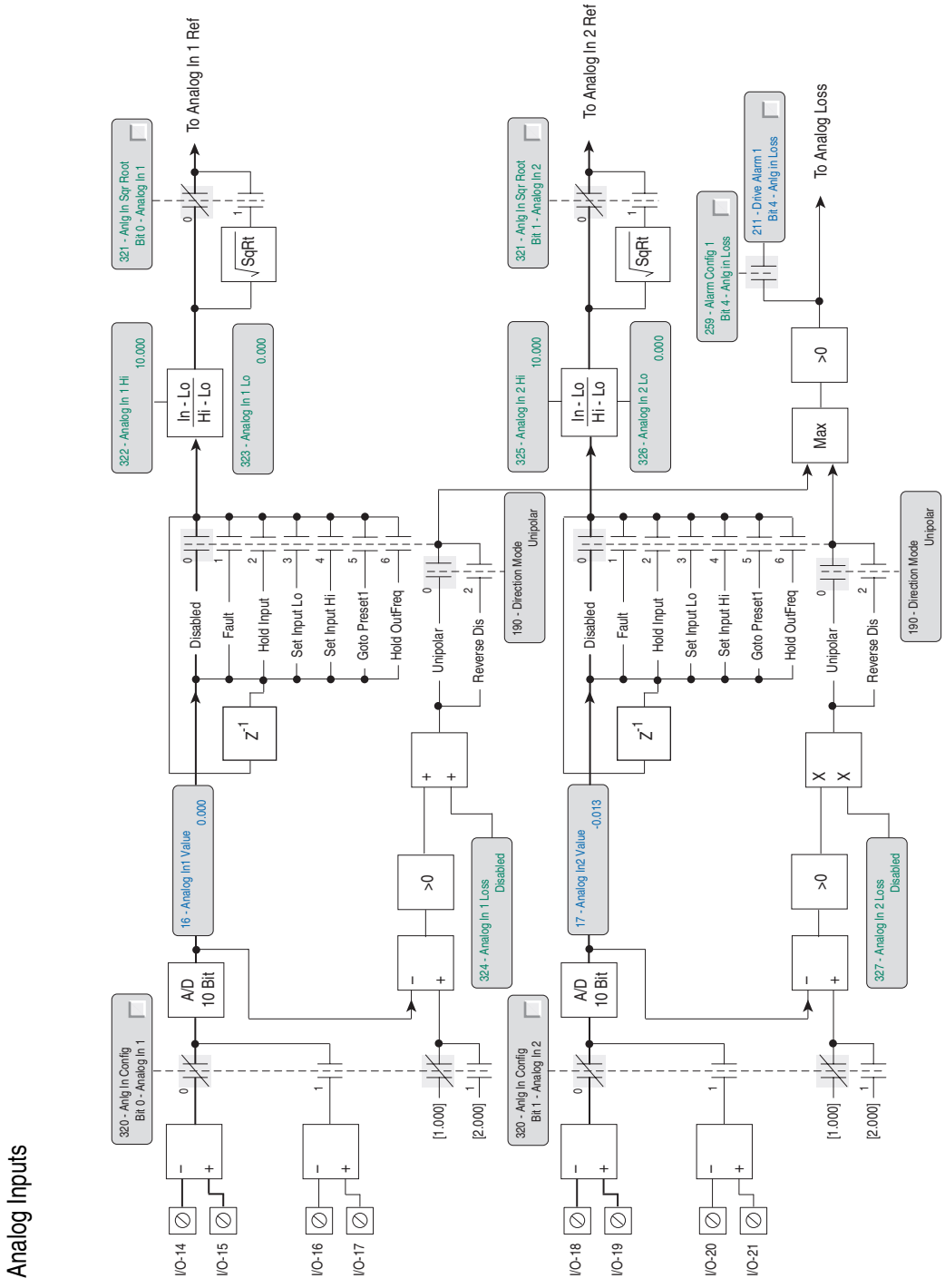
Torque Current (continued)


Inverter Over Load (IT)
Power Device Characteristics
NTC
Pwr EE Data
Duty Cycle
Heat Sink and Junction Degree Calculator
(see Torque Block)
3 - Output Current 0.00 Amps
12 - DC Bus Voltage 682.7 VDC
148 - Current Lmt Val 22.0 Amps
150 - Drive OL Mode Both-PWM 1st
151 - PWM Frequency 4 kHz
211 - Drive Alarm 1 Bit 7 - Drv OL Lvl 1
211 - Drive Alarm 1 Bit 8 - Drv OL Lvl 2
218 - Drive Temp 17.8 %
219 - Drive OL Count 0.0 %
234 - Testpoint 1 Sel 499
236 - Testpoint 2 Sel 499
235 - Testpoint 1 Data 0
237 - Testpoint 2 Data 0
DB Resistor
DC Bus
161 - Bus Reg Mode A Adjust Freq
162 - Bus Reg Mode B Both-Frq 1st
163 - DB Resistor Type None
210 - Drive Status 2 Bit 7 - DB Active
211 - Drive Alarm 1 Bit 5 - IntDBRes OH
Mtr Over Load (I2T)
Motor Current
150%
102%
Right of Curve
60 (Hot)
180 (Cold)
Time (Sec)
48 - Motor OL Factor 1.00
42 - Motor NP FLA 12.3 Amps
X
47 - Motor OL Hertz 20.0 Hz
1.0 - 2.0 (1.025 Typ)
50%
Motor Speed (Hz)
210 - Drive Status 2 Bit 12 - Motor Overl
220 - Motor OL Count 0.0 %

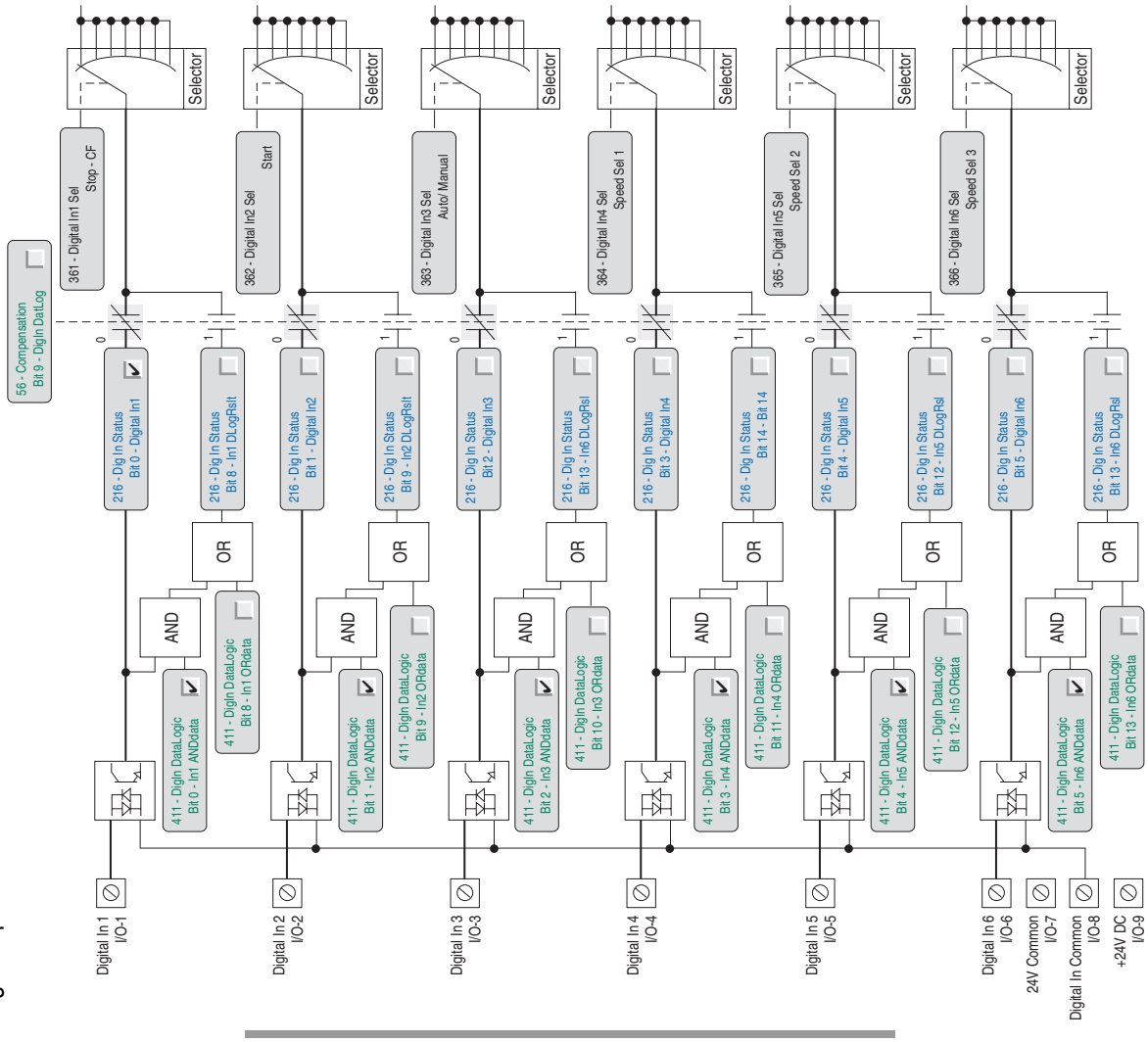
Control Inputs & Outputs Overview



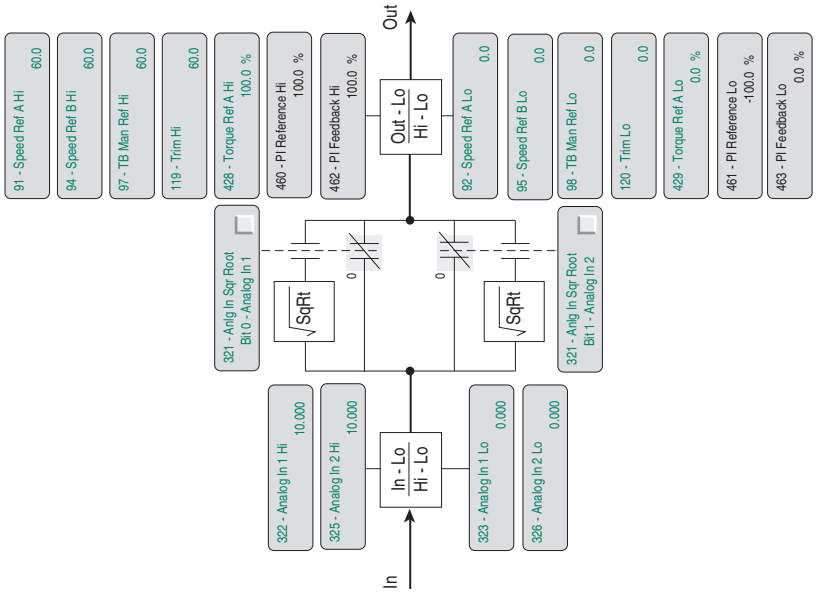
Analog Inputs


To Analog In 1 Ref
To Analog In 2 Ref
To Analog Loss
320 - Anlg In Config Bit 0 - Analog In 1
320 - Anlg In Config Bit 1 - Analog In 2
321 - Anlg In Sqr Root Bit 0 - Analog In 1
321 - Anlg In Sqr Root Bit 1 - Analog In 2
322 - Analog In 1 Hi 10.000
323 - Analog In 1 Lo 0.000
325 - Analog In 2 Hi 10.000
326 - Analog In 2 Lo 0.000
259 - Alarm Config 1 Bit 4 - Anlg In Loss
211 - Drive Alarm 1 Bit 4 - Anlg In Loss
A/D 10 Bit
In - Lo
Hi - Lo
SqRt
Max
>0
Disabled
Fault
Hold Input
Set Input Lo
Set Input Hi
Goto Preset1
Hold OutFreq
Unipolar
Reverse Dis
190 - Direction Mode
16 - Analog In1 Value 0.000
17 - Analog In2 Value -0.013
324 - Analog In 1 Loss Disabled
327 - Analog In 2 Loss Disabled
[1.000]
[2.000]
I/O-14
I/O-15
I/O-16
I/O-17
I/O-18
I/O-19
I/O-20
I/O-21

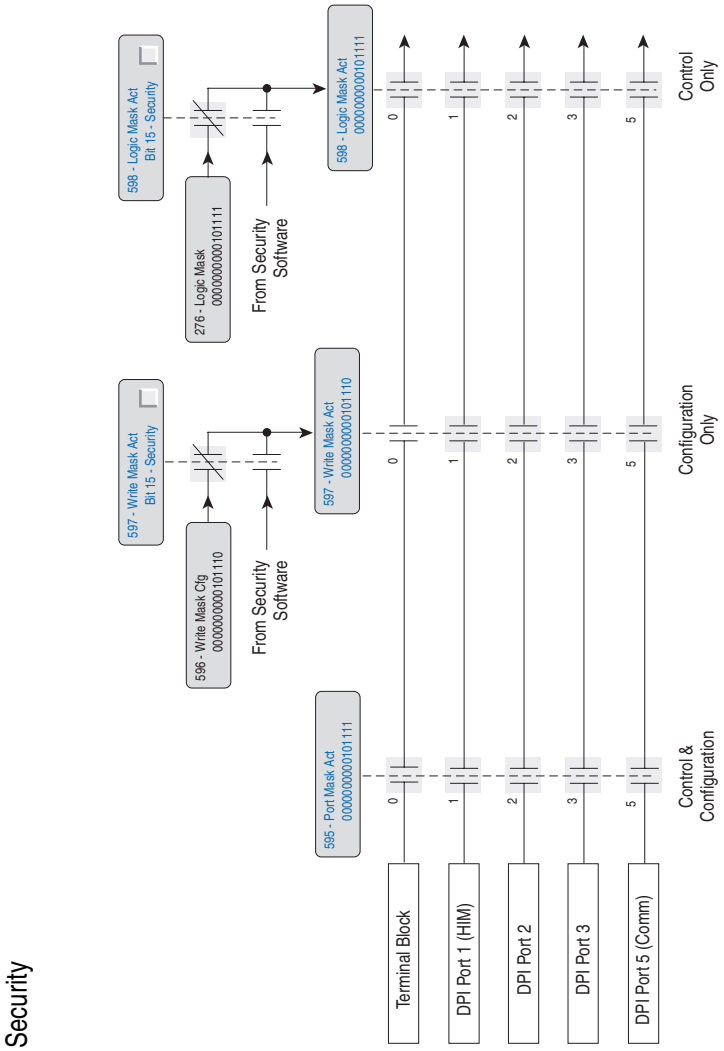
Digital Inputs


56 - Compensation
Bit 9 - DigIn DatLog
361 - Digital In1 Sel
Stop - CF
362 - Digital In2 Sel
Start
363 - Digital In3 Sel
Auto/ Manual
364 - Digital In4 Sel
Speed Sel 1
365 - Digital In5 Sel
Speed Sel 2
366 - Digital In6 Sel
Speed Sel 3
Selector
216 - Dig In Status
Bit 0 - Digital In1
Bit 8 - In1 DLogRslt
Bit 1 - Digital In2
Bit 9 - In2 DLogRslt
Bit 2 - Digital In3
Bit 13 - In6 DLogRsl
Bit 3 - Digital In4
Bit 14 - Bit 14
Bit 4 - Digital In5
Bit 12 - In5 DLogRsl
Bit 5 - Digital In6
Bit 13 - In6 DLogRsl
AND
OR
411 - DigIn DataLogic
Bit 0 - In1 ANDdata
Bit 8 - In1 ORdata
Bit 1 - In2 ANDdata
Bit 9 - In2 ORdata
Bit 2 - In3 ANDdata
Bit 10 - In3 ORdata
Bit 3 - In4 ANDdata
Bit 11 - In4 ORdata
Bit 4 - In5 ANDdata
Bit 12 - In5 ORdata
Bit 5 - In6 ANDdata
Bit 13 - In6 ORdata
Digital In 1 I/O-1
Digital In 2 I/O-2
Digital In 3 I/O-3
Digital In 4 I/O-4
Digital In 5 I/O-5
Digital In 6 I/O-6
24V Common I/O-7
Digital In Common I/O-8
+24V DC I/O-9

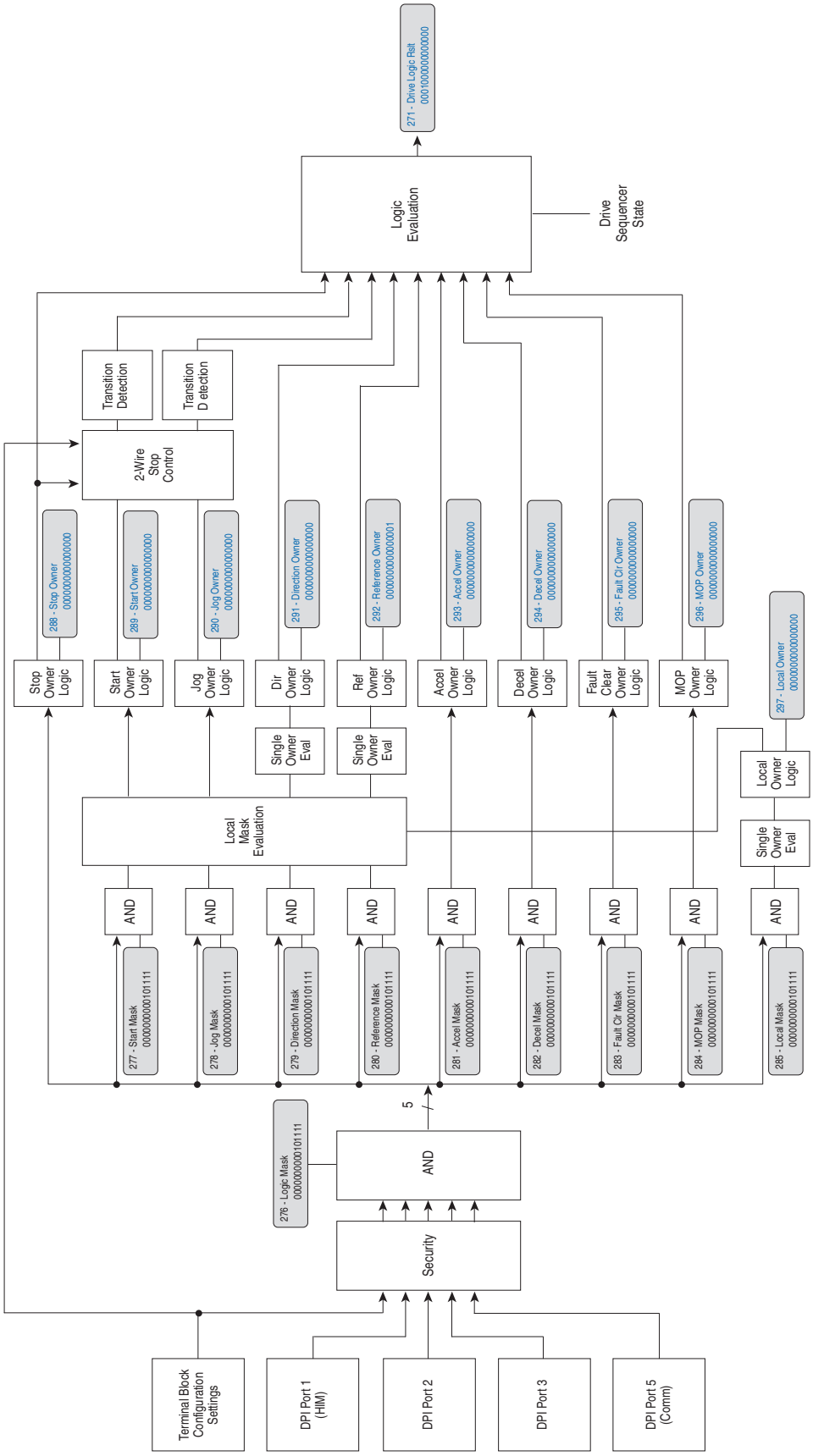
Analog Inputs (continued)


91 - Speed Ref A Hi 60.0
94 - Speed Ref B Hi 60.0
97 - TB Man Ref Hi 60.0
119 - Trim Hi 60.0
428 - Torque Ref A Hi 100.0 %
460 - PI Reference Hi 100.0 %
462 - PI Feedback Hi 100.0 %
Out - Lo
Hi - Lo
Out
92 - Speed Ref A Lo 0.0
95 - Speed Ref B Lo 0.0
98 - TB Man Ref Lo 0.0
120 - Trim Lo 0.0
429 - Torque Ref A Lo 0.0 %
461 - PI Reference Lo -100.0 %
463 - PI Feedback Lo 0.0 %
321 - Anlg In Sqr Root
Bit 0 - Analog In 1
Bit 1 - Analog In 2
SqRt
322 - Analog In 1 Hi 10.000
325 - Analog In 2 Hi 10.000
In - Lo
Hi - Lo
In
323 - Analog In 1 Lo 0.000
326 - Analog In 2 Lo 0.000

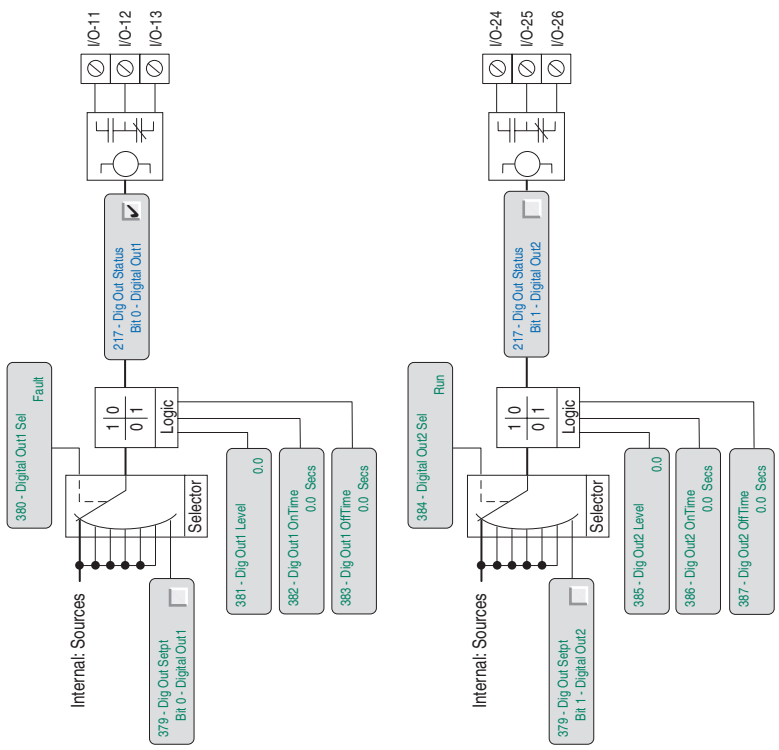
Security


595 - Port Mask Act
0000000000101111
596 - Write Mask Cfg
0000000000101110
From Security Software
597 - Write Mask Act
Bit 15 - Security
597 - Write Mask Act
0000000000101110
276 - Logic Mask
0000000000101111
From Security Software
598 - Logic Mask Act
Bit 15 - Security
598 - Logic Mask Act
0000000000101111
Terminal Block
DPI Port 1 (HIM)
DPI Port 2
DPI Port 3
DPI Port 5 (Comm)
0
1
2
3
5
Control & Configuration
Configuration Only
Control Only

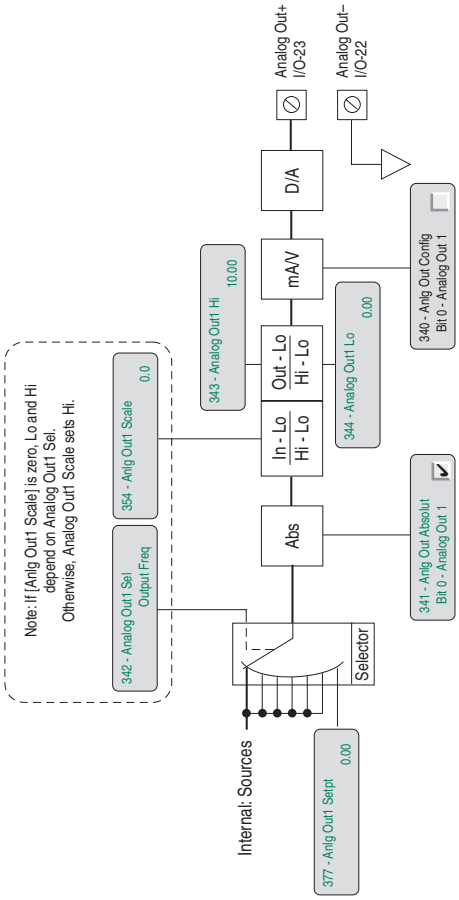
Control Logic



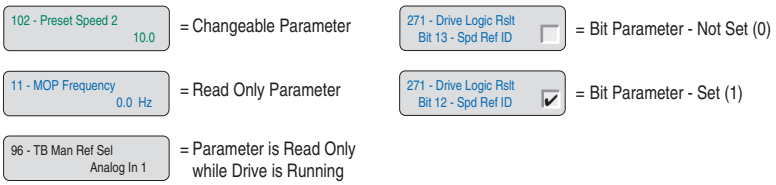
Digital Output



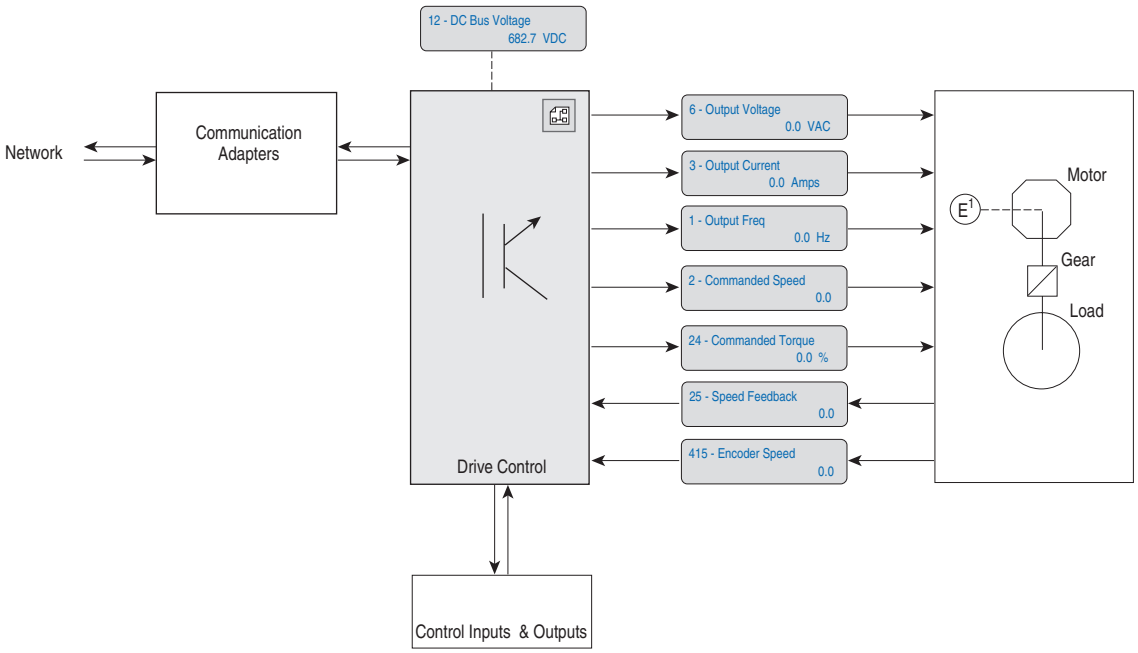
Analog Output



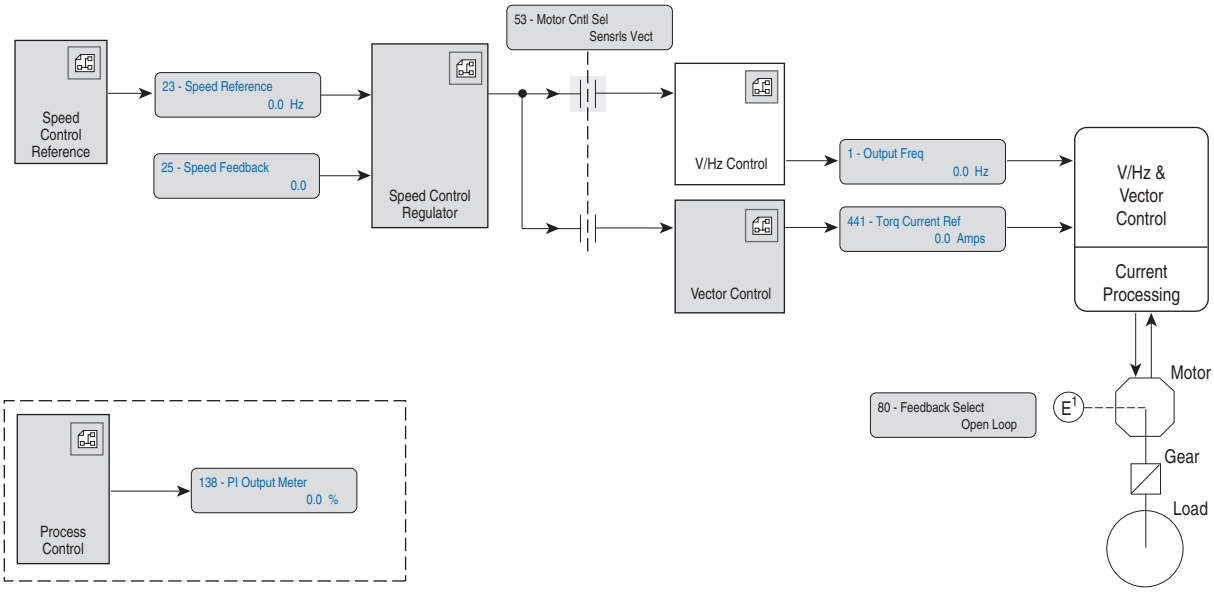
PowerFlex 700VC Block Diagrams


102 - Preset Speed 2
10.0
= Changeable Parameter
11 - MOP Frequency
0.0 Hz
= Read Only Parameter
96 - TB Man Ref Sel
Analog In 1
= Parameter is Read Only while Drive is Running
271 - Drive Logic Rslt
Bit 13 - Spd Ref ID
= Bit Parameter - Not Set (0)
271 - Drive Logic Rslt
Bit 12 - Spd Ref ID
= Bit Parameter - Set (1)

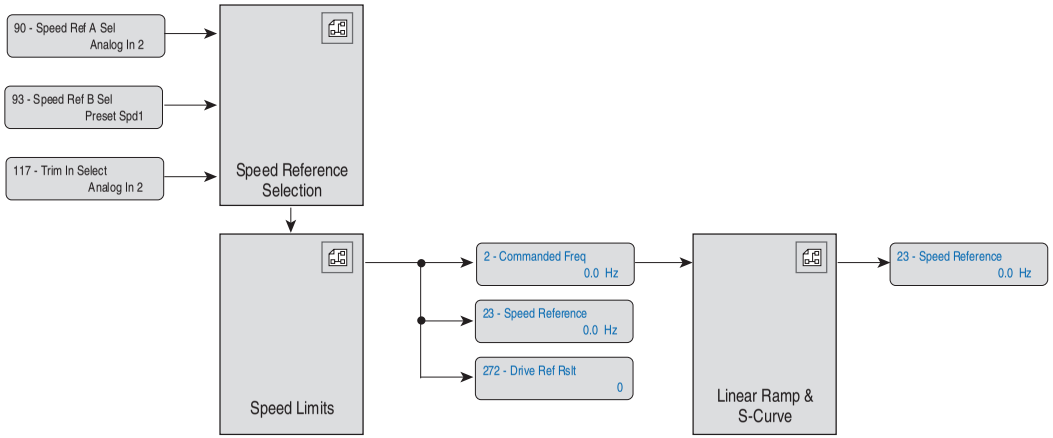
Drive Overview



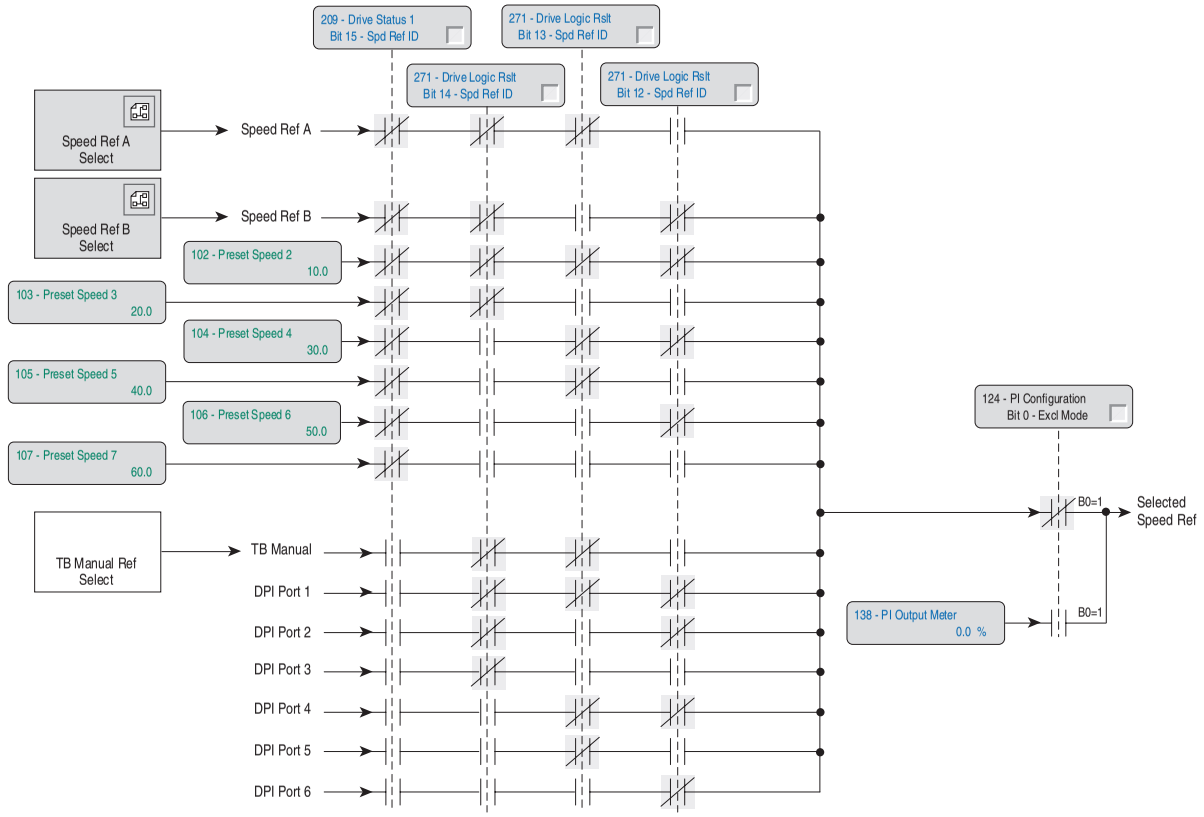
Control Overview

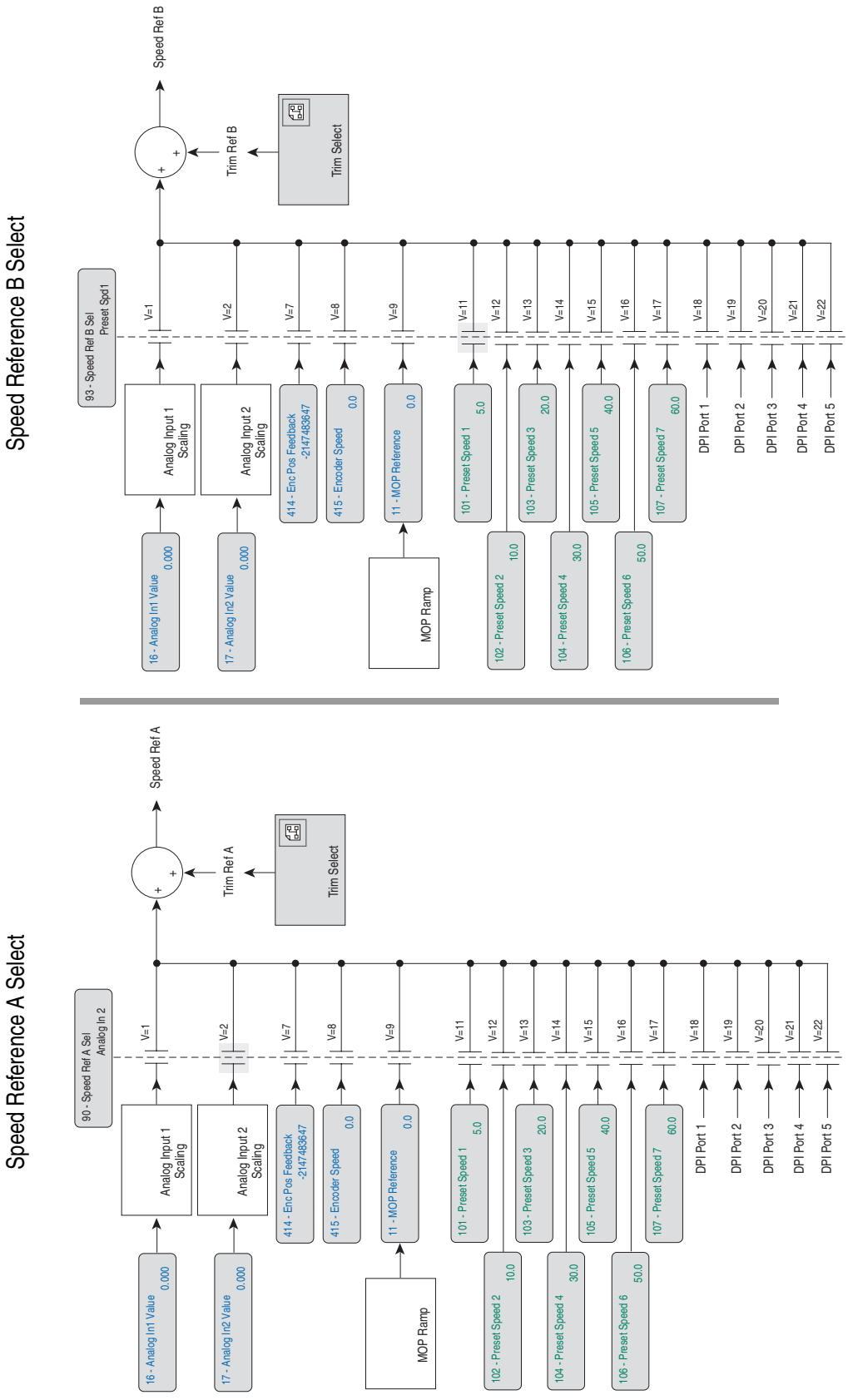


Speed Control Overview

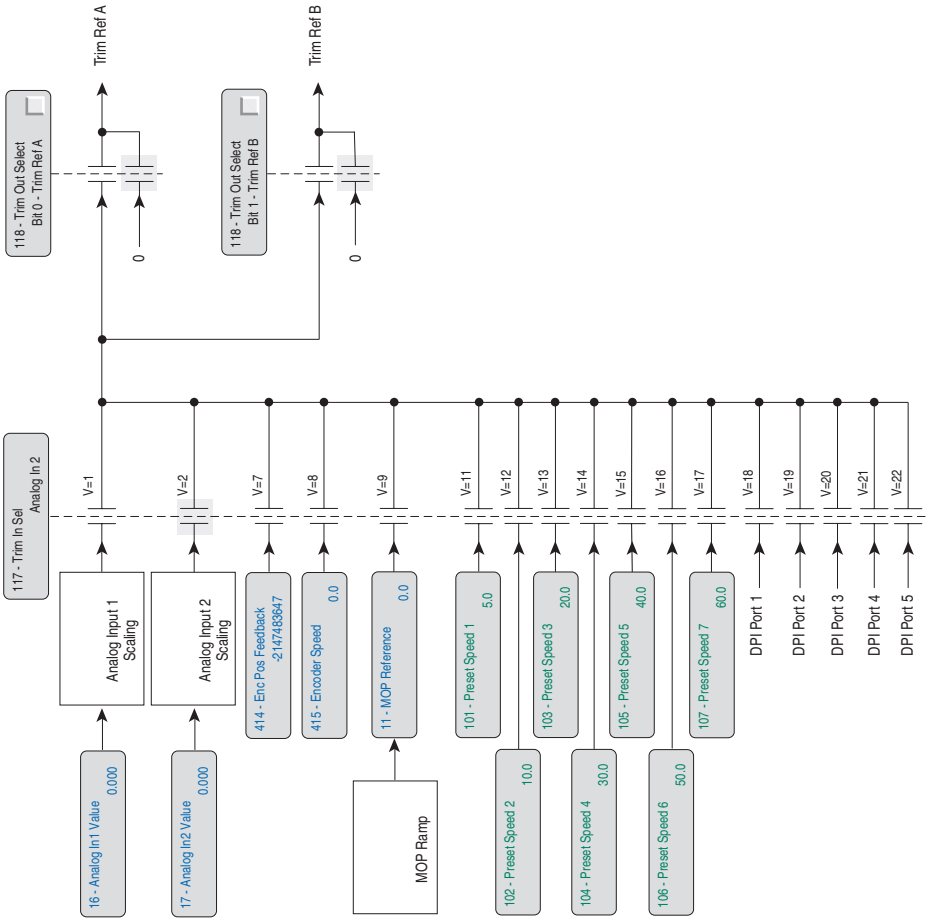


Speed Reference Select

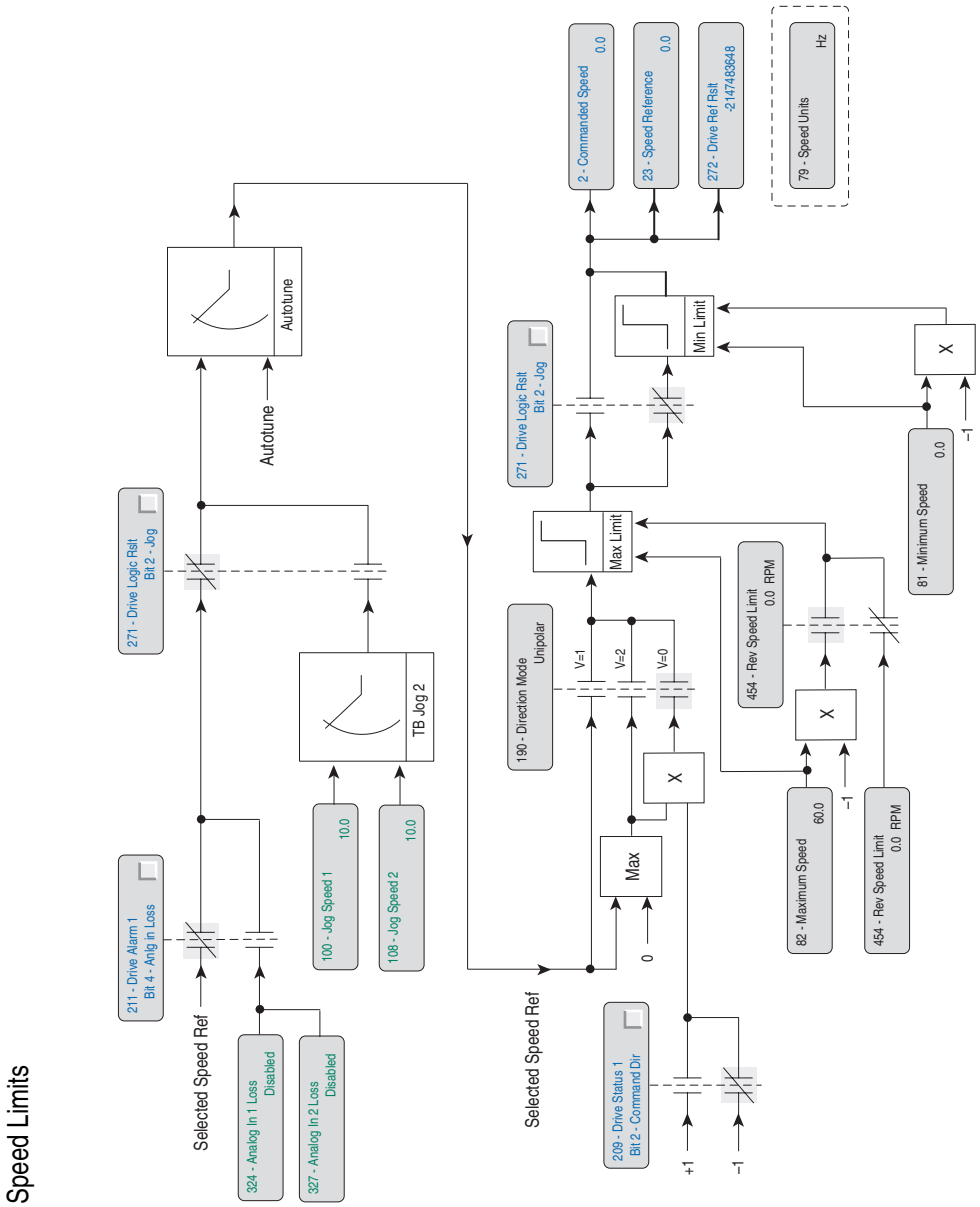



Speed Reference A Select
90 - Speed Ref A Sel
Analog In 2
Analog Input 1 Scaling
Analog Input 2 Scaling
16 - Analog In1 Value 0.000
17 - Analog In2 Value 0.000
414 - Enc Pos Feedback -2147483647
415 - Encoder Speed 0.0
11 - MOP Reference 0.0
MOP Ramp
101 - Preset Speed 1 5.0
102 - Preset Speed 2 10.0
103 - Preset Speed 3 20.0
104 - Preset Speed 4 30.0
105 - Preset Speed 5 40.0
106 - Preset Speed 6 50.0
107 - Preset Speed 7 60.0
V=1
V=2
V=7
V=8
V=9
V=11
V=12
V=13
V=14
V=15
V=16
V=17
V=18
V=19
V=20
V=21
V=22
DPI Port 1
DPI Port 2
DPI Port 3
DPI Port 4
DPI Port 5
Trim Ref A
Trim Select
Speed Ref A
Speed Reference B Select
93 - Speed Ref B Sel
Preset Spd1
Analog Input 1 Scaling
Analog Input 2 Scaling
16 - Analog In1 Value 0.000
17 - Analog In2 Value 0.000
414 - Enc Pos Feedback -2147483647
415 - Encoder Speed 0.0
11 - MOP Reference 0.0
MOP Ramp
101 - Preset Speed 1 5.0
102 - Preset Speed 2 10.0
103 - Preset Speed 3 20.0
104 - Preset Speed 4 30.0
105 - Preset Speed 5 40.0
106 - Preset Speed 6 50.0
107 - Preset Speed 7 60.0
V=1
V=2
V=7
V=8
V=9
V=11
V=12
V=13
V=14
V=15
V=16
V=17
V=18
V=19
V=20
V=21
V=22
DPI Port 1
DPI Port 2
DPI Port 3
DPI Port 4
DPI Port 5
Trim Ref B
Trim Select
Speed Ref B

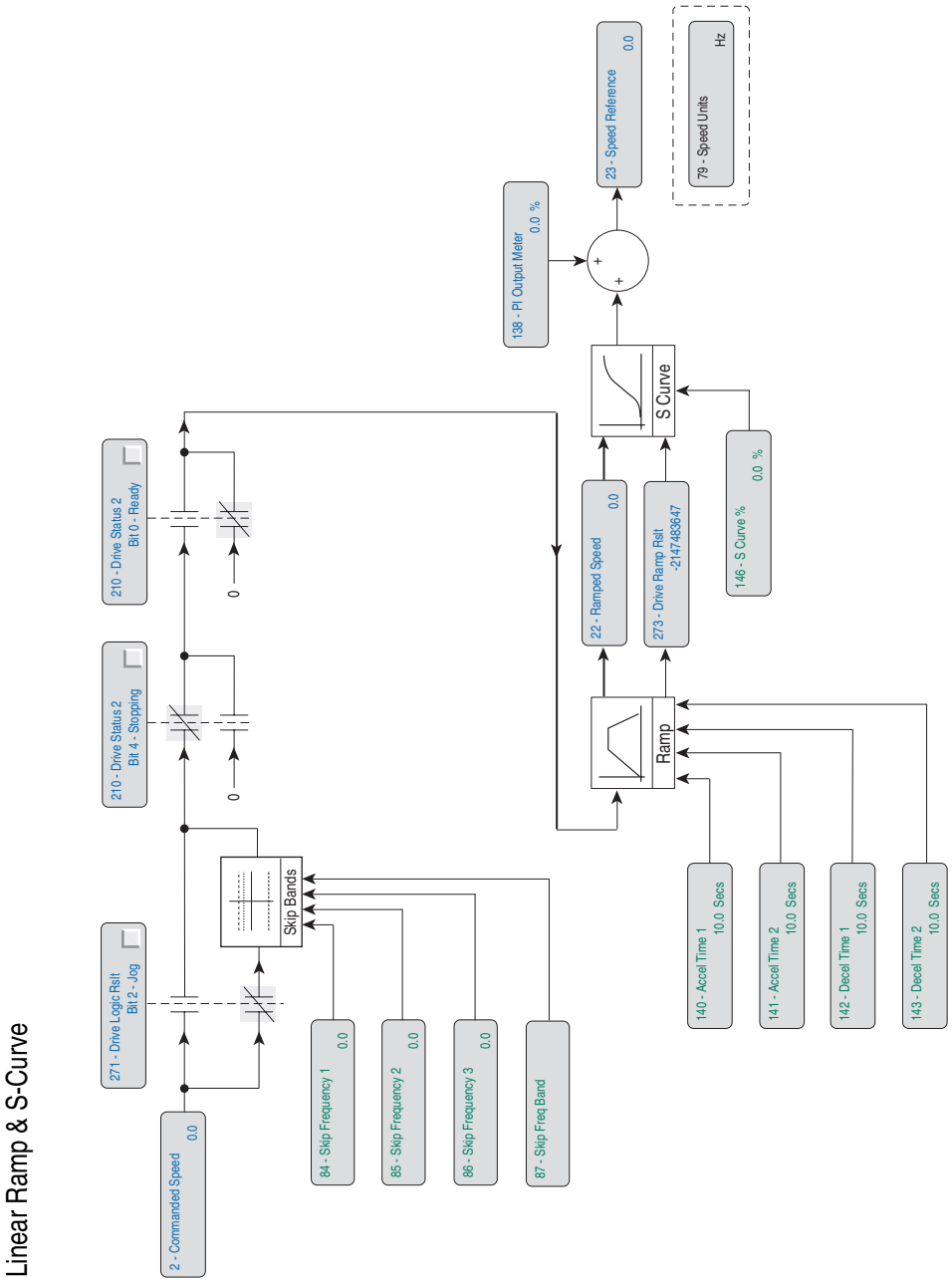
Trim Select


Trim Ref A
Trim Ref B
118 - Trim Out Select Bit 0 - Trim Ref A
118 - Trim Out Select Bit 1 - Trim Ref B
0
0
117 - Trim In Sel
Analog In 2
V=1
V=2
V=7
V=8
V=9
V=11
V=12
V=13
V=14
V=15
V=16
V=17
V=18
V=19
V=20
V=21
V=22
Analog Input 1 Scaling
Analog Input 2 Scaling
414 - Enc Pos Feedback -2147483647
415 - Encoder Speed 0.0
11 - MOP Reference 0.0
101 - Preset Speed 1 5.0
103 - Preset Speed 3 20.0
105 - Preset Speed 5 40.0
107 - Preset Speed 7 60.0
DPI Port 1
DPI Port 2
DPI Port 3
DPI Port 4
DPI Port 5
16 - Analog In1 Value 0.000
17 - Analog In2 Value 0.000
MOP Ramp
102 - Preset Speed 2 10.0
104 - Preset Speed 4 30.0
106 - Preset Speed 6 50.0

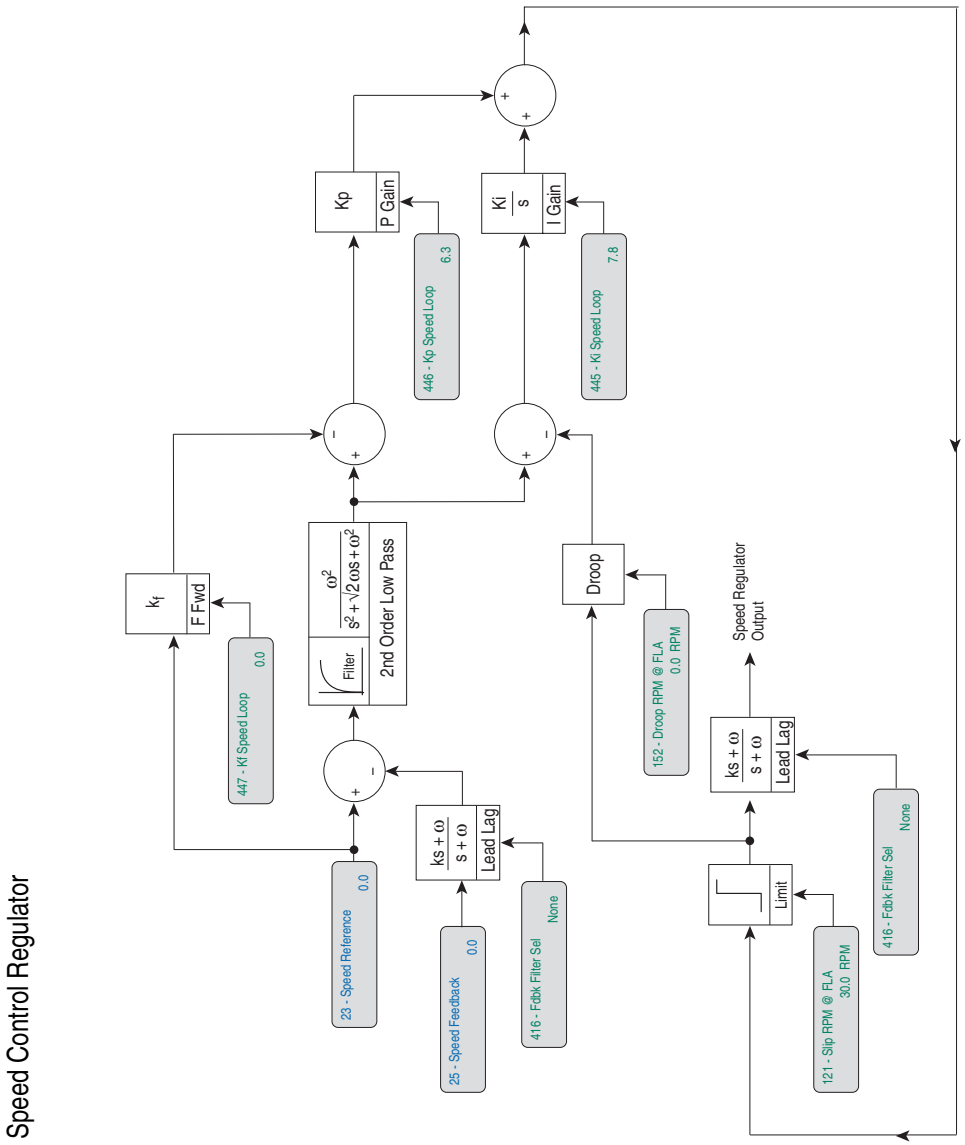
Speed Limits



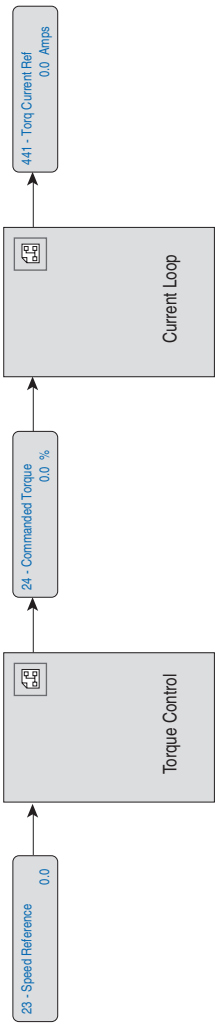
Linear Ramp & S-Curve


2 - Commanded Speed 0.0
271 - Drive Logic Rslt Bit 2 - Jog
210 - Drive Status 2 Bit 4 - Stopping
210 - Drive Status 2 Bit 0 - Ready
Skip Bands
84 - Skip Frequency 1 0.0
85 - Skip Frequency 2 0.0
86 - Skip Frequency 3 0.0
87 - Skip Freq Band
Ramp
140 - Accel Time 1 10.0 Secs
141 - Accel Time 2 10.0 Secs
142 - Decel Time 1 10.0 Secs
143 - Decel Time 2 10.0 Secs
22 - Ramped Speed 0.0
273 - Drive Ramp Rslt -2147483647
S Curve
146 - S Curve % 0.0 %
138 - PI Output Meter 0.0 %
23 - Speed Reference 0.0
79 - Speed Units Hz

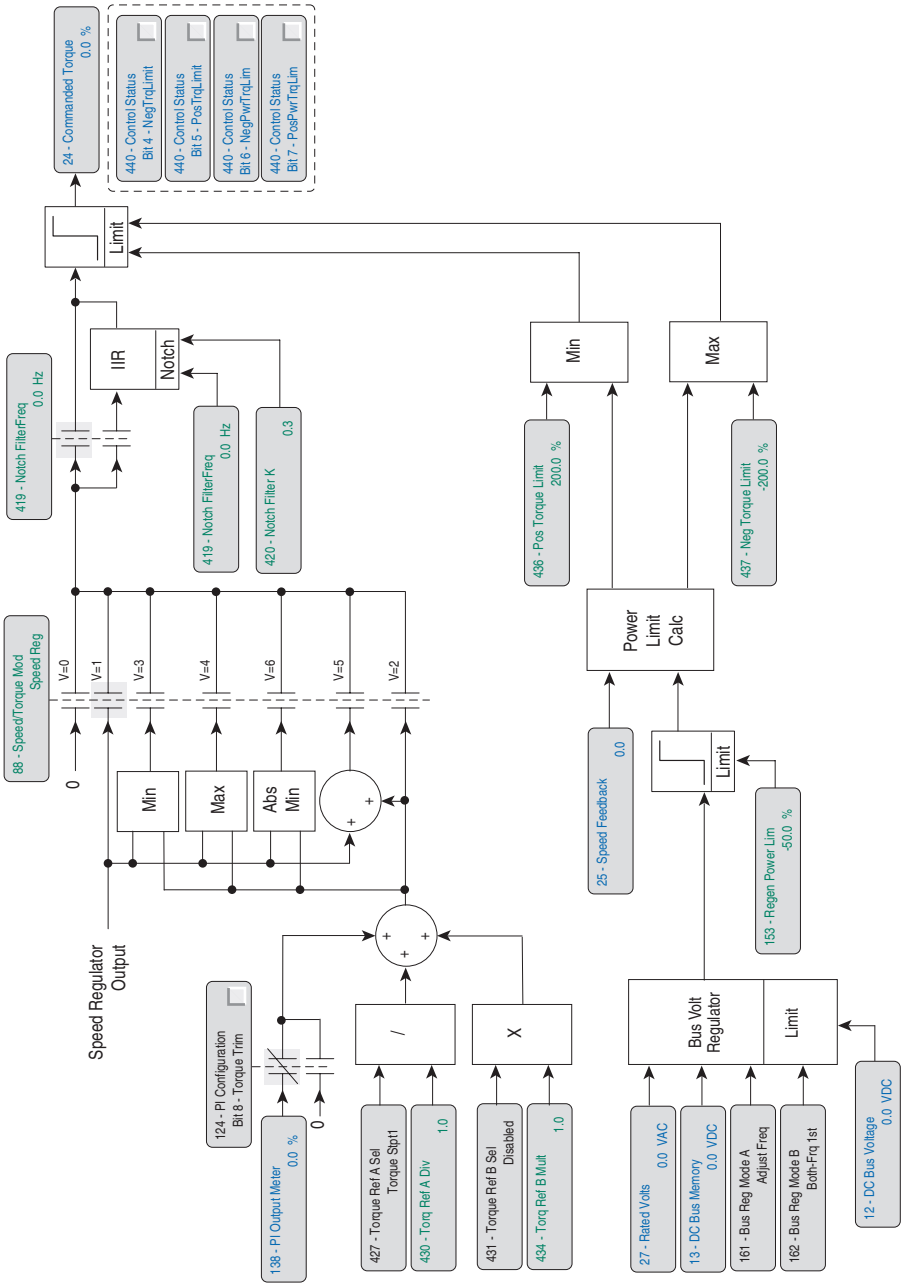
Speed Control Regulator


Kp
P Gain
446 - Kp Speed Loop 6.3
Ki / s
I Gain
445 - Ki Speed Loop 7.8
kf
F Fwd
447 - Kf Speed Loop 0.0
ω² / s² + √2ωs + ω²
Filter
2nd Order Low Pass
Droop
152 - Droop RPM @ FLA 0.0 RPM
Speed Regulator Output
ks + ω / s + ω
Lead Lag
23 - Speed Reference 0.0
25 - Speed Feedback 0.0
416 - Fdbk Filter Sel None
Limit
121 - Slip RPM @ FLA 30.0 RPM
416 - Fdbk Filter Sel None

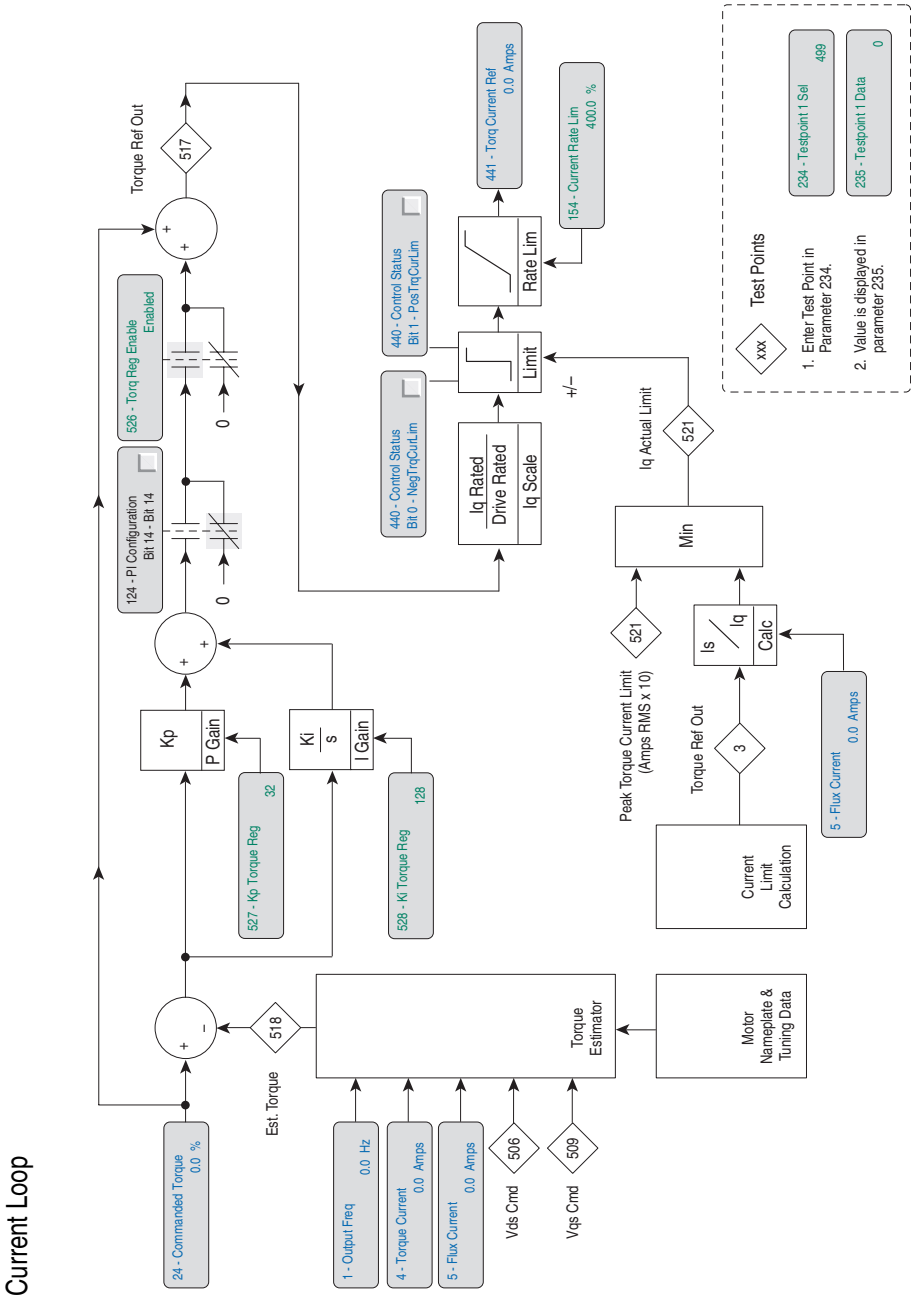
Vector Control Overview



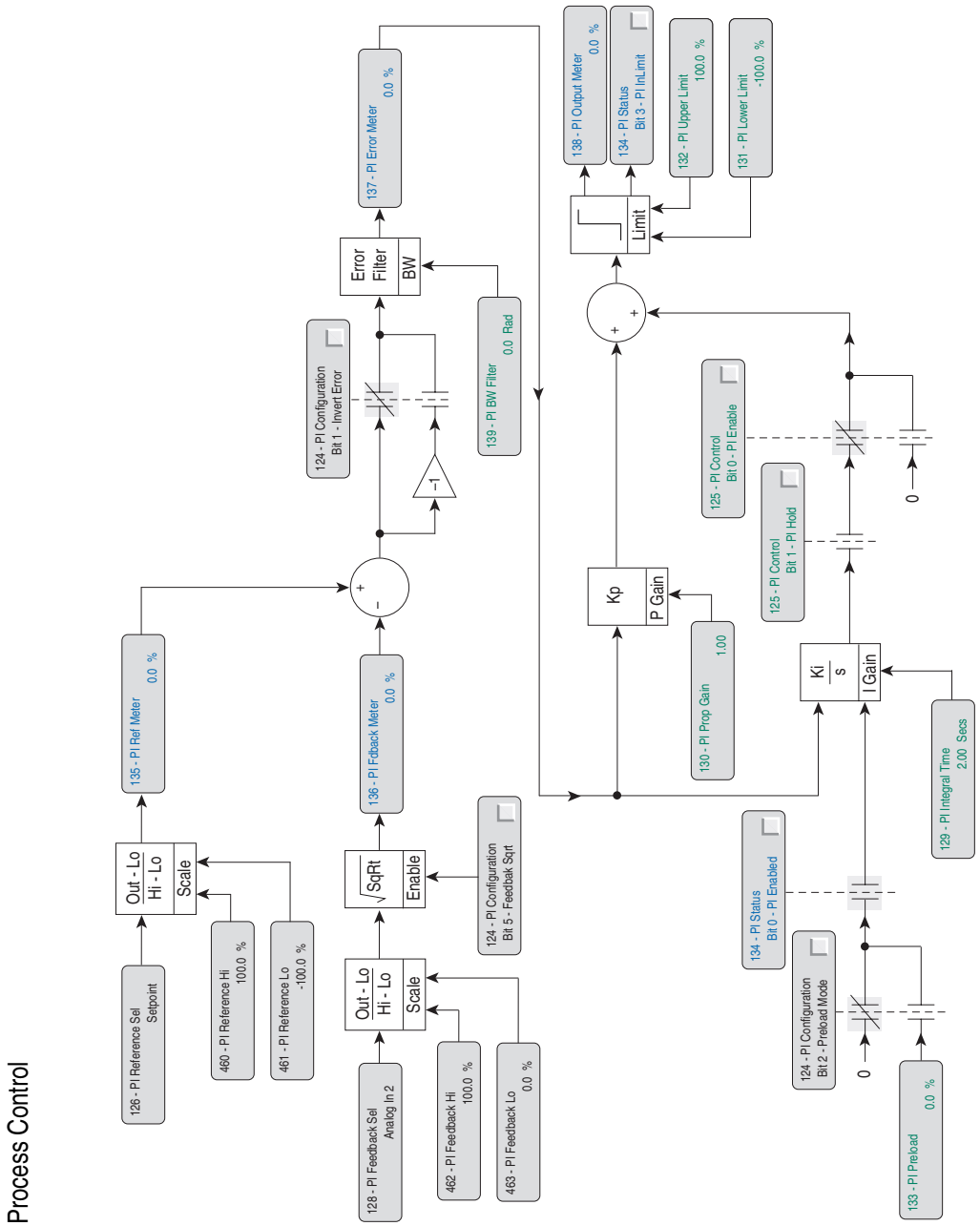
Torque Control Overview


24 - Commanded Torque 0.0 %
440 - Control Status Bit 4 - NegTrqLimit
440 - Control Status Bit 5 - PosTrqLimit
440 - Control Status Bit 6 - NegPwrTrqLim
440 - Control Status Bit 7 - PosPwrTrqLim
Limit
IIR
Notch
419 - Notch FilterFreq 0.0 Hz
419 - Notch FilterFreq 0.0 Hz
420 - Notch Filter K 0.3
88 - Speed/Torque Mod Speed Reg
V=0
V=1
V=3
V=4
V=6
V=5
V=2
0
Min
Max
Abs Min
Speed Regulator Output
124 - PI Configuration Bit 8 - Torque Trim
138 - PI Output Meter 0.0 %
0
427 - Torque Ref A Sel Torque Stpt1
430 - Torq Ref A Div 1.0
431 - Torque Ref B Sel Disabled
434 - Torq Ref B Mult 1.0
436 - Pos Torque Limit 200.0 %
437 - Neg Torque Limit -200.0 %
Min
Max
Power Limit Calc
25 - Speed Feedback 0.0
Limit
153 - Regen Power Lim -50.0 %
Bus Volt Regulator
Limit
27 - Rated Volts 0.0 VAC
13 - DC Bus Memory 0.0 VDC
161 - Bus Reg Mode A Adjust Freq
162 - Bus Reg Mode B Both-Frq 1st
12 - DC Bus Voltage 0.0 VDC

Current Loop



Process Control



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U.S. Allen-Bradley Drives Technical Support - Tel: (1) 262.512.8176, Fax: (1) 262.512.2222, Email: support@drives.ra.rockwell.com, Online: www.ab.com/support/abdrives

www.rockwellautomation.com

Power, Control and Information Solutions Headquarters

Americas: Rockwell Automation, 1201 South Second Street, Milwaukee, WI 53204-2496 USA, Tel: (1) 414.382.2000, Fax: (1) 414.382.4444
Europe/Middle East/Africa: Rockwell Automation, Vorstlaan/Boulevard du Souverain 36, 1170 Brussels, Belgium, Tel: (32) 2 663 0600, Fax: (32) 2 663 0640
Asia Pacific: Rockwell Automation, Level 14, Core F, Cyberport 3, 100 Cyberport Road, Hong Kong, Tel: (852) 2887 4788, Fax: (852) 2508 1846

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